Volume 25.
Number 4.

DECEMBER, 1911.

$3.00 a Year.
$1.00 a Number.

BURTON O. PHILBRICK
1014 BROADWAY
OAKLAND, - - CAL.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION,

715 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 700 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT,—the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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New England Water Works Association.

ORGANIZED 1882.

Vol. XXV. **December, 1911.** **No. 4.**

This Association, as a body, is not responsible for the statements or opinions of any of its members.

COMING EFFICIENCY IN WATER-WORKS MANAGEMENT.

BY W. H. RICHARDS, ENGINEER AND SUPERINTENDENT OF WATER AND SEWER DEPARTMENT, NEW LONDON, CONN.

[*Read September 13, 1911.*]

Much has been written of late of scientific efficiency, the aim being to get a greater return with less effort, but behind this movement is the increasing desire to promote that efficiency which saves material as well as labor and thus reduces cost of output. So strongly has this idea taken hold of the people that the day is nor far distant when the management of at least all the larger corporations both public and private will be judged by the resulting cost.

So far as water departments either public or private are concerned, this will first manifest itself in the cities of medium size. And it is important that this society consider some of the ways in which this demand must be met, and it is with this in view that this paper is presented.

Whatever of criticism will be found in this paper applies with equal force to private companies or public corporations, as lack of efficient management is found as often in one as in the other, and in the final analysis the public pays in each case.

To promote the greatest efficiency the board of managers or commission, by whatever name it may be called, should be non-political and its duties should be strictly separated from the executive part of the work, being confined to matters of general policy, approval of expenditures, appropriations, general plans, formula-

tion of rules, etc., appointment and removal of subordinates being made only on recommendation of the general manager, superintendent, engineer, commissioner, or whatever title may be given to the executive head, for upon the latter rests or should rest mainly the responsibility for the efficiency of the work. For the remainder of this paper he will be referred to as the superintendent.

What kind of a man should the superintendent be? Not necessarily an engineer in the sense of being a graduate with a "sheepskin," but he certainly should be an engineer in the larger sense that he should be ingenious, capable of interpreting a drawing or making one if necessary, with a thorough knowledge of construction and tools, and he must have or immediately acquire a knowledge of the fundamental principles of hydraulics, and over and above all else he should understand the principles of business management. Such a man, it is perhaps unnecessary to state, cannot be secured for twelve or fifteen hundred dollars per year. If the organization be a new one, several years must elapse in experiments, and usually the "fads and fancies" of the superintendent have to be tried out and their utility tested. Even with the above qualifications he has much to learn, for the management of water works requires much special knowledge.

The powers of the superintendent should be large, and to secure the greatest efficiency he should have a voice in the appointment of his subordinates as well as the power to recommend discharge after proper hearing, for efficiency cannot be secured without discipline by a single responsible head. With such an organization the economy in conducting the work will be improved from year to year; efficiency without economy is impossible. Many policies have been settled by experience, and most of them have been put in print, but there remains much that is experimental, and the solution of many problems must be left to the ingenuity of the superintendent as they arise. For instance, while the efficiency of the cast-iron mains has been pretty thoroughly tested with most waters, the life and coatings of steel mains are still problematical. The size of mains necessary in certain places offers a wide field for ingenuity and thought on the part of the superintendent; so with the service pipe; except in special qualities of water, lead is almost universally used, yet the regulation of the size is subject

to wide variation dependent on the pressure and quantity of water necessary or desirable to be supplied in a given time, and the regulation of the size calls for even more consideration than the size of the mains, for the theory that a certain quantity of water will go through a certain sized hole regardless of the length of the pipe is one of the most common errors of the ignorant and unthinking.

I believe no one has yet discovered the best water meter, yet there is a chance to exercise considerable judgment of the kind or type for different circumstances or uses, and if the board of managers insist on selecting the cheapest without regard to material or construction, the result will be disastrous to the efficiency of the meter department.

The conclusions of sanitary experts are changing every minute and the superintendent must have a very logical mind to separate the theoretical from the practical.

What about the composition of the board of directors? The corner grocery or professional politics do not usually fit men for undertaking large affairs, and a man who never handled a hundred dollars in his life is somewhat bewildered when given $100 000 to spend. Some men are so constituted that they magnify a dollar to cartwheel size; others have so little knowledge of its value, especially when it belongs to some one else, as to ignore its size altogether. The first, while saving cents, will lose dollars, and the second will lose both. The best proof of a man's ability to manage large undertakings for other people is that he has managed his own large business successfully. A board of managers, for instance, when buying land or rights, may in their effort to drive a sharp bargain overreach and get into a lawsuit which will cost many times the amount saved. Another board may saddle the city or company with a filter or an expensive reservoir unnecessary for the time being at least.

In construction or extension of the work where it is necessary to engage a designing engineer, the superintendent may give advice which should always be given consideration. For the design of work is one thing and the care of it another. Many a superintendent has been worried into the grave trying to adapt an impractical scheme designed by an engineer without experience in management.

The board when selecting its designing or consulting engineer might remember that a six weeks' trip to Europe does not make an engineer, and might well consider if an expensive filter or massive dam is necessary. The interest account of many a city or company is burdened with the cost of an extravagant structure built but to gratify the fad of the designing engineer.

A celebrated foreign engineer on viewing a large water-works dam once said that "any fool could build a dam if he could use a large enough factor of safety."

It should be borne in mind that every gallon of water has a fixed value and that that value is dependent on the cost and capacity of the work and the expense of maintaining it. No work can be run efficiently until this fact is recognized and understood. If the rates are so regulated that one man gets two gallons for the price of one, then the man who uses one gallon and pays for it pays part of the other man's water rate.

The cost of the water system and its maintenance should be borne by the consumer of water and, except as to that part of the expenditure necessary for the extinguishment of fires, in proportion to the amount of water used.

The practice of furnishing water free to the city departments, hospitals, and other institutions which may make a plausible plea to the board, as well as the practice of furnishing extra fire protection free to certain parties who are patrons of certain insurance companies, is not only unjust to the rate payers, but makes a statement of the measure of efficiency impossible.

If it is thought necessary to lay out a park or pleasure ground on lands controlled by a public water department, why not charge it to the park department? What has tree culture to do with the conduct of a water system?

Many cities have tons of lead service pipe where they will never be used, laid with the expectation of preventing the disturbance of the pavement which other public service corporations dig up without hindrance. It has become necessary in one large city to expose the mains and shut off these unused extra service pipes to prevent leakage.

Few water departments make any account of water furnished to other city departments, and, on the other hand, few water depart-

ments make remuneration for damage to streets. A precise system of accounting would stop many leaks in a water-works system. In fact, it is usually impossible to tell whether the works are efficiently managed or not from the published accounts. A balance sheet is of rare occurrence in a water report, and an inventory or any charge for depreciation still more rare.

The president of one water company furnishes all water pipe used, and a relative furnishes all coal, without competition; the water taker pays for both, in high rates. The superintendent has been dismissed, being of a too prying disposition. Another water company has all outside work done by a relative of the president on a percentage. What is more common than for one member of the board to interfere with details of the management of a department? — and the more ignorant he is the more likely he is to interfere.

Of what use is a meter system when 30 per cent. of the water is wasted by poorly jointed pipe and 20 per cent. by the waste in public buildings?

Efficiency can only be effected by order and system coming through one responsible head, and that head must be more or less of an autocrat, each subordinate being in turn responsible to the one above.

In this age when improvements in methods and means of transacting business are constantly being introduced, it requires constant study and clear discernment to find and apply the device or method necessary for the particular work.

In a city of considerable size it is impossible for the superintendent to observe every detail of the work, and he will accomplish more in his office than in his automobile, but he must first acquire a knowledge of the work and his subordinates by observation. At his desk he decides a multitude of problems, from the color of paint to quality of yarning, from the probable registry of an obstructed meter to the efficiency of his pumps; and all the time he must know what each subordinate is doing and what he is going to do the next day.

This in general is an outline of some of the things necessary to have and a few of the things to avoid in an efficient water-works system, and the efficiency is measured by the cost of the water

supplied, taking into consideration its quantity and the necessary expense to secure and distribute it.

As mentioned above, the time is fast approaching when the constantly increasing indebtedness of water supply systems will attract the public attention and managers will be held strictly accountable to the public. Until that time comes, the following description of the water-works superintendent by President Alvord, of the American Water Works Association, will hold good: "He has held out to him no alluring pension as a reward for the honest, faithful, and nerve-racking care and service he gives, but is haunted day and night by fear of a broken main, failure of water supply, or of disease traceable to the water. He has trouble securing funds for procuring the necessary equipment, and, above all, has to deal, always courteously but firmly, with the ever-present infuriated citizen who insists he is not getting his just dues from a government he helps support."

How can efficiency be best promoted? I should say by system carefully thought out, by having order everywhere, and by well-defined rules thoroughly and impartially enforced.

DISCUSSION.

MR. A. E. MARTIN. Mr. President, I presume that every one here who has anything to do with water works in Massachusetts has felt the effect of the eight-hour law, so-called, and I think we will feel it more as time goes on. The chances are that some of us may find ourselves up against a one thousand dollar fine and imprisonment for six months, more or less, if the judge who has the case to try happens to be one of our disappointed customers. I think it is going to be a pretty hard problem to do our work in eight hours a day, or forty-eight hours a week, and make the system as efficient as it ought to be.

The rule I propose to adopt, as far as I can, is this: That my first duty is to see that every customer gets his water when he wants it, and when he ought to have it, and if I have to infringe the law to do that, some one will have to back me up. It would not take many one thousand dollar fines to eat up my yearly

salary, and my family would feel its effects, if I had more than one such fine to pay in the course of the year.

MR. RICHARDS. What Mr. Martin has said with regard to the eight-hour law puts me in mind of something which I should have mentioned, perhaps, in my paper. It is a question whether a man can accomplish as much work in nine hours as he can in ten, provided the men working with him are equally efficient; but you have got to have a limit somewhere, of course, and when you put it at eight hours I doubt if it holds true. I do think, however, that in nine hours an ordinary man, if he is efficient, will do about as much work as he would in ten. I have just been notified by a walking delegate that my men must work only eight hours, so I am beginning to think over the question myself a little.

MR. MARTIN. Mr. President, it has just been suggested to me that some of our members, who are not Massachusetts men, may not know exactly what the Massachusetts eight-hour law means. For their information I might say that during the past four years there has been a constant effort made to secure the passage of a law whereby no municipal employee should be *allowed* to work over eight hours in any one day, or forty-eight hours in a week. Such a law was passed by the legislature and twice vetoed by Governor Draper, but this year it has been signed by Governor Foss, after a certain feature had been eliminated by the Supreme Court. As the law now stands, if a man by working a little overtime has any extra time to his credit at the end of the week, so that, for instance, he has worked forty-eight hours in five days, he *must* lay off the remainder of the week. The penalty for each infringement of the law is a fine of one thousand dollars, or imprisonment for six months in jail, or both. That applies to the man who is responsible, and is supposed to be the superintendent.

It strikes me that the various water boards will have to stand in the breach and back us up, for I don't think there are many superintendents who would care to spend six months in jail or even pay a fine of one thousand dollars. But that is what we are up against now. I think perhaps if municipal officials had realized as much about it before the law was passed as they do now, they might have appeared at the State House and attempted to prevent the passage of the bill, although I hardly believe they would have been suc-

cessful. The movement has been under way three or four years, and the labor men were bound to put it through, and now they have got the law I doubt if it will ever be repealed. It may prove to be unconstitutional, and I believe it will, if a test case is ever brought, but I don't know of anybody who wants to stand up and test it. I certainly do not, for one.

MR. A. L. SAWYER. Don't you understand that in cases of emergency the men can work overtime?

MR. MARTIN. Yes. In the case of an emergency, when there is a break or anything of that kind, which is going to cut off the water supply, we are allowed to work overtime.

MR. SAWYER. In Haverhill our superintendent is striving to keep within the law as well as he can, and in case of a break that has to be attended to he keeps on file a separate record of it, under the head of "Emergency Work," and that will be open to the state police inspectors. I doubt if the inspectors will get around very often, for this is a big state for them to cover.

MR. MARTIN. I will say in answer to Mr. Sawyer that I do not think it is the state police who are going to interfere with us as much as it is the agents of the labor unions, and those people who used to be called "walking delegates."

MR. SAWYER. The foreman of our street department has told me that the men in the street department in Haverhill are against the law.

MR. T. J. CARMODY. I think, Mr. President, that Mr. Martin is wrong in his interpretation of the law. If a question of the public health is involved, you can work the men over forty-eight hours, and I think myself the law is a good one. I am in favor of it, because I think there are a good many men employed in the departments who, without such a law, would have to work a good deal overtime. If a man works forty-eight hours a week, working day or night, I don't see why he shouldn't then be entitled to lay off. I think eight hours a day is long enough for any man to work, and I think he can really accomplish as much in eight hours as he can in nine. A man can do but a certain amount of work anyway, and my experience in my own line of business has been that a man can do just as much in eight hours as when he was working nine or working ten hours.

MR. ARTHUR A. REIMER. The paper presents a subject that I think we all have studied more or less unconsciously, that is, without calling it "Efficiency in Water-Works Management." I think we all, as men interested in some line of endeavor, be it the management of a water plant or the designing of some engineering structure, strive to get the best results possible, if we are true to our calling; and, therefore, we are efficiency students to that extent, though we may not apply that particular term to it.

The author stated that eventually the measure of efficiency is going to be cost. I could not fully agree with that statement, for, without knowing that others were going to mention this eight-hour matter, I had in mind several elements, one of which was this very question of the eight-hour law. A man who is working under the stress of a definite law with an eight-hour limit certainly cannot compare his work and the results accomplished with the work done by another man working under no restriction as to time and working the usual and customary term of ten hours with his men. I think some other standard of comparison will have to be used than the standard of cost. We must measure the results accomplished by some other element than the financial one. I am not overlooking the fact that local conditions produce very different results and costs in different localities, but the cost is not necessarily the proper basis of comparison of efficiency, even when an analysis includes the effect of local conditions.

I agree fully with the position the author has taken with regard to the attitude which should be assumed by the head of the department. The author used the term "autocrat," and I do not believe that a better term can be used to describe the position which should be occupied by such a man when it comes to the question of the employment and discharge of men occupying positions under him or the executive management of the department. If we are to be held responsible for results accomplished in our departments, and I think we all regard our department as ours, and if we have the interest of the department at heart, we certainly should have full control of the department. Responsibility without authority is as bad a condition as taxation without representation.

I think that is the attitude that we all should seek to occupy

with regard to the management of the various departments. I cannot speak about the private companies, because I have never had any connection with one of them, but certainly in municipal work, where politics enters to such an extent, if we are going to get good results I believe it is our duty to stand firm and say that we must have full power. If we cannot I am afraid it will be a case of wreck the department or resign. The commission idea that is sweeping the country at present, and is so much talked of, has as one of its basic principles the fixing of individual responsibility, and that same principle applied to the water department means that the superintendent or engineer, or whatever his title may be, must be the executive power in that department, although of course the governmental work, when it comes to laws and so on, must be carried on by the City Council, or the Commission, or whatever body it may be that is the administrative head of the city.

We are troubled with the eight-hour law down in New Jersey. It has come to us this year as an unwelcome present. We are allowed to work the men overtime in case of emergency, but they have to be paid for it. To meet the situation in our department I told the various foremen and assistants that I wanted them to endeavor to get as much work done in the eight hours as they had formerly in ten. I said that was what they should strive for; I did not tell them they would have to get it, for I did not know that it would be possible. I have been interested in comparing the results during the past few months with the results accomplished under the old ten-hour rule, and I find that by constant prodding of the foremen, they can get nearly as much work done with their gangs in eight hours as they formerly did in ten, and I should be glad to hear what others have been able to do along this line. We have not worked under the eight-hour law for a full year yet, so I cannot give a year's results, but at present we are getting along fairly well under the eight-hour rule. It means, of course, that the foremen are working up to a higher standard of efficiency, that is what it comes down to, because they are using their brains to devise schemes to save work which was formerly done, perhaps uselessly, and the department would, therefore, seem to be working on a higher plane of efficiency on

the labor end. But other features of the eight-hour law make it highly objectionable, and largely, if not fully, offset any advantages that may come from it.

MR. M. N. BAKER. It seems to me that attention should be given to a functional classification of water-works administration with a view to working out a basis of cost of service. Such statistics as have been compiled in the past have been largely valueless because they do not get down to the bottom facts which should govern and instruct a water-works superintendent. It is earnestly to be desired that all water-works men should join together in working out some better forms. Just how this can be done is too large a question to enter upon at this time; possibly it might be worthy of consideration by a committee of the Association at some future date.

MR. W. C. HAWLEY. I am particularly interested in this eight-hour proposition, Mr. President. If the time which the superintendent has to spend in Massachusetts measures up with what the superintendents elsewhere have to spend, I can see where he will have Saturday and possibly Friday and maybe some of Thursday off most every week. I think I will apply for a position in Massachusetts.

In addition to the qualifications of a manager, which Mr. Richards has mentioned, I think he ought also to be something of a lawyer. I have found in connection with municipal plants that you cannot always depend upon the political lawyers who are connected with the city government, and have found in connection with privately owned plants that a good many questions come up which must be decided when there is no time for consultation with an attorney.

This matter of efficiency is one which is receiving a great deal of attention, and one which needs to be considered in the water-works business, especially in municipally owned plants. I think that as a rule the privately owned plants, the larger ones at any rate, have been obliged to give a great deal of attention to the subject; but such investigations as I have made as to municipally owned plants show a large mixture of politics with business, and generally not for the good of the plant.

Incidentally, there is much that we water-works men can learn

from the decisions of the Wisconsin Railroad Commission in the carrying out of the Public Utility Law of the State of Wisconsin. The work which has been done by that board in analyzing the costs of plants and the costs of the different kinds of service has been very interesting, instructive, and helpful. The decisions have certainly surprised those municipalities that have come in contact with the law. This is especially true in the case of the municipal plant of the city of Madison, and also in the case of the City of Beloit *v.* The Beloit Water, Gas, and Electric Company. A summary of this latter decision was published in the *Engineering Record* of September 2. These municipalities have been surprised to learn what it costs to furnish fire protection. The water companies have had this matter forced upon their attention because so few of them receive anything like an adequate return for the furnishing of fire protection and water for other municipal uses. In nearly every case they have been obliged to charge a rate for domestic service which would cover part of the cost and, generally, a large part of the cost of furnishing water for fire protection and other municipal purposes and to get from the municipalities what they can for these services. In both the Madison and Beloit cases, the Wisconsin Commission decided that very much less than the proper amount for furnishing fire protection had been allowed and that when a proper charge for those services had been made the rates for domestic service should be materially reduced.

MR. BAKER. It happens that only yesterday I was talking with the chief engineer of the Wisconsin Railroad Commission, and what he had to say, with what had already come to my attention, bears out the statement of the last speaker to the effect that the work of that commission is well worthy of the study of all water-works men. The commission are entering upon their work with zeal and with an unusual degree of wisdom, and trying to get to the bottom of the various problems which they are called upon to solve, and to do it in a way, as it should of course be done, which will be for the interest of the people who are being served by the public service corporations, and who are being served by the municipalities, for they have control of the municipally owned plants as well as of the privately owned plants.

MR. GEORGE A. KING. Mr. President, there is one thing which

Mr. Richards suggested which, it seems to me, is worthy of considerable thought, and it is right along the line which men are employing in other work, — that is, that a carefully thought-out plan in the office is of great value in reducing the cost of work. I think we ought to give a great deal more thought to the matter of designing work in the office and laying out our plans there, and by doing that we can save money.

Mr. Richards. As to the standard of cost, of course the cost of one hundred per cent. of efficiency must be different in every work, because it will be governed by different things, such as the remoteness or nearness of the source of supply, whether the water is pumped or not, and so on; and there are so many variations that each individual plant must be judged by itself. The basis of one hundred per cent. is different in each case, and hence the cost per gallon must be different in each case; and the fallacy of comparing the water rate in one town with the water rate in another is apparent, when we come to think of it.

I fully agree with Mr. Hawley in what he said about law; but, after all, law is simply good horse sense, when you come right down to it, and you can't have efficiency without horse sense.

I meant to have referred to the Wisconsin Commission, because what extracts I have seen from their decisions have been of immense help to me, and have put any quantity of ideas into my head. I don't know but what the records of the Wisconsin Commission would come next to the Journal of the New England Water Works Association in value.

The President. I saw some doubt expressed in the faces of the members when you stated your proposition, Mr. Richards, that law is nothing but horse sense.

Mr. Richards. Perhaps I ought to have said "justice."

The President. I think that amendment will be accepted.

Mr. Frank L. Fuller. Referring again for a moment to the eight-hour law, I wonder if anybody can tell by the activity which they display, when he sees men at work, whether they are working eight hours a day or whether they are working nine hours? It seems to me that eight hours is a pretty short day for men to work in water-works construction. There are a great many things to get ready and plan out, and the eight hours is up almost, —

I wouldn't say before you get started, but it is a pretty short day.

MR. RICHARDS. I think I am in favor of an eight-hour law for the superintendents, and it occurs to me that it might be worked out in this way: You could have three superintendents and they could each go on duty for four hours. That would be very easy. The salary would of course remain the same.

MR. MARTIN. That is the point I thought of when Mr. Carmody suggested that forty-eight hours a week was enough. I think forty-eight hours a week *is* enough for the laboring man; eight hours a day *is* enough for the ordinary working day. But when it comes to the superintendent, or the man in charge, what about him? Does he work forty-eight hours a week, or does he work twenty-four hours a day? I have been employed in this kind of work for upwards of thirty years, and I never yet have felt that my day's work was done when I went home at night. I have never felt like going out of town unless I could leave somebody to look after my work while I was away. The work of the water department is going on day and night, twenty-four hours out of the twenty-four, and the superintendent has it on his mind all the time. It is not merely eight hours a day for him, but he is on duty the whole twenty-four. I think eight hours a day is enough for a regular day's labor, but when it says that a man shall not be *allowed* to work occasionally ten hours a day if he wants to, and make a little more money by it, I think the law is going beyond its province in denying a man that privilege.

MR. W. H. RICHARDS (*by letter*). Any increase in efficiency must finally in the long run result in a saving, either a saving in maintenance, reduction in first cost, or a reduction in liability to excessive cost. Take, for instance, a dam; if built of excessive strength at excessive cost, the interest on that excessive cost must be paid forever. On the other hand, if weakly constructed, to save money, it finally goes down, causing great damage and great cost. It is apparent that it lacks efficiency in both cases. Again, if a pipe system is so constructed as to reduce the cost of repairs per mile below the average, the efficiency of the works is increased and that efficiency is measured by the reduction in the cost of repairs.

An elaborate system of locating mains and other underground

fixtures may require a considerable expenditure of time and thought, and will surely result after a time in the saving of money.

And so it will be found on careful analysis that efficiency or lack of efficiency can always be reduced to dollars and cents.

A SHORT ACCOUNT OF SOME PURIFICATION EXPERIMENTS WITH A SURFACE WATER IN QUEENSLAND, AUSTRALIA.

BY HARDOLPH WASTENEYS, ROCKEFELLER INSTITUTE OF MEDICAL RESEARCH, NEW YORK.

[*Read September 14, 1911.*]

The following is a short account of some experiments conducted by the writer on behalf of the Brisbane Board of Water Works in order to determine the best practical method of purifying the Enoggera Reservoir, one of that city's sources of supply.

These experiments were conducted over a period of four years from 1904 to 1908. Unfortunately, many of the data accumulated during this period are not, at the moment of writing, available to the author, but there are sufficient to cover the principal features of the experiments.

The Enoggera Reservoir, which has a capacity of about 1 000 million gallons, contains surface water collected over a catchment area of 12.9 square miles, which is for the most part fairly heavily timbered with eucalyptus, with a large proportion of a comparatively dense undergrowth.

This area is under the control of the board, there are no human habitations permitted on the watershed, and it is also patrolled, so that there is, practically speaking, no danger of bacterial contamination. The objectionable quality of the water is due to the presence of tastes, odors, and ferrous iron in the water reaching the consumer.

The quality of this supply has been a source of reproach to the city almost ever since its inception and the Board of Water Works have obtained many reports and have conducted many series of experiments with the object of ascertaining some practical method of rendering it more suitable for a town supply.

The following table will serve to give some idea of the atmospheric temperature at the reservoir throughout an average year,

the figures quoted being those for the year 1906, the last year for which the writer has an available record.

AVERAGE DAILY MEAN SHADE TEMPERATURES AT FILTERS IN 1906.
DEGREES FAHRENHEIT.

January	77.7
February	76.0
March	72.7
April	70.6
May	63.5
June	58.4
July	54.8
August	58.4
September	60.1
October	67.5
November	72.0
December	74.0

The experimental filters used in the investigation under discussion were situated close to the reservoir, so that the above table also serves to indicate the conditions at the filter site.

The reservoir contains very heavy growths of fresh-water plants, water lilies, Myriophyllum, Ceratophyllum, etc., and there is a considerable accumulation of organic matter in the silt at the bottom.

There is only one overturning of the reservoir contents during the year, occurring about the month of May. This is due to the fact that the temperature of the water is never low enough to reach the point where water attains maximum density, which phenomenon in a less mild climate is the cause of a second overturning. As a consequence, the water is stagnant at depths below 19 ft. for eleven months out of the twelve, and these conditions are very favorable to putrefactive processes. Thus, from a depth of 20 ft. downwards, the water, except during the annual overturning, contains little to no oxygen and the iron contents show a corresponding increase. At 20 ft. from the bottom, at a place where the reservoir had a depth of 60 ft., the data at hand indicate iron in solution to as much as 50 parts per million.

The comparatively high and long-continued summer temperatures, the large proportion of shallows in the reservoir, the long stagnation period, strong light, and high organic content of the

water are all in favor of an abundant growth of algæ, especially the bluegreens, with their accompaniment of disagreeable odors and tastes, and this growth indeed takes place. Clathrocystis grows most abundantly, while Anabæna and Oscillaria are also often plentiful. Synedra sometimes occurs in such quantity as to render the surface water quite opalescent, and Peridinium is also frequently present in large numbers. The water has nearly always a moderately offensive odor, not always so noticeable at the reservoir itself, but more so at the consumer's end of the pipe. The trouble is augmented by growths of Plumatella, Cordylophora, and Sponge in the mains.

Plumatella grows very densely in the pipes at the inlets to the service mains, and in the autumn, when it usually begins to decay, it becomes detached from the pipes and disintegrates, thus causing much additional trouble in the shape of a new variety of offensive odors and mechanical obstruction to faucets, meters, etc.

The composition of the reservoir water is given in Table 1, containing analytical results obtained during the year 1906. The samples for analysis were collected during a period of one hour at the inlets to the various experimental filters, the idea being to obtain a fair average sample of the water applied to all the filters.

This water was drawn through a short length, about 100 yd. of 16-in. cast-iron main, collecting water from a depth of 5 ft. below the surface of the reservoir at a point about 60 yd. from the bank in the deepest portion of the reservoir. In this table, as well as in the other tables of analyses to follow, the methods used were, with one or two exceptions, those recommended by the American Committee on Standard Methods of Water Analysis.

As already indicated, and as is usual with waters of this type, the main object sought to be attained by purification of the water, was the removal of tastes, odors, color, and iron. To this end many types of filters and processes were tried. It would be tedious and unprofitable to describe in detail all these processes, and it will suffice to survey briefly the results obtained by the more important ones.

The first experiments with which the writer was concerned were with coagulants and rapid filtration. Alum and lime were the coagulants used, and the rate of filtration varied up to 130

TABLE 1.

ENOGGERA RESERVOIR WATER DRAWN FIVE FEET BELOW SURFACE.

Monthly Averages of Analyses.

Month. 1906.	Number of Determinations (except where otherwise shown in parentheses).	Temperature of Water at Time of Collecting Sample.	PARTS PER MILLION.										BACTERIA PER C.C. INCUBATED 48 HOURS.		Odor (Cold).
			AMMONIA.		Oxygen Consumed at 90° F.		Total Iron.	Chlorine (Cl).	Alkalinity (as $CaCO_3$).	Free Carbonic Acid (CO_2).	Color. (Platinum Scale.)	Dissolved Oxygen.	98° F. Neutral Agar.	68° F. Neutral Gelatine.	
			Free.	Albuminoid.	15 minutes.	4 hours.									
January	8	79.8	.05	.35	2.6	4.5	.22	35	38 (7)	....	49*	6.2 (5)	1230 (2)	.....	Strong vegetable.
February	7	79.9	.05	.33	2.5	4.4	.23	35	38	....	52*	5.9 (3)	325 (1)	.....	Strong vegetable.
March	1	76.5	.06	.34	2.8	4.6	.40	34	24	3.5	67*	.....	.....	.....	Very strong vegetable.
April	3	76.0	.04	.25	2.5	4.5	.29	32(2)	27	2.9	51*	.....	.....	.....	Strong vegetable.
May	3	67.8	.05	.21	2.3	4.2	.65	29(2)	29	8.3	80*	.....	.....	.....	Strong vegetable.
June	4	63.4	.06	.25	2.1	4.0	.56	28	28	3.0	51*	6.9 (2)	150 (2)	800 (1)	Distinct and nil.
July	5	59.4	.04	.28	2.0	3.9	.47	28	29	2.2	44*	8.8 (4)	605 (2)	987 (2)	Nil.
August	4	60.7	.04	.31	1.9	3.8	.41	29	30	3.0	35*	9.0 (2)	350 (2)	.....	Slight.
September	2	66.7	.02	.31	1.8	4.0	.41	29	29	3.7	32 (1)	.....	.....	.....	Slight and distinct.
October	5	74.3	.02	.27	1.8	3.4	.37	27	30	4.8	32	7.0 (1)	325 (1)	.....	Distinct.
November	4	77.6	.04	.24	1.6	3.2	.31	30	32	3.2	23	6.7 (2)	.....	.....	Distinct.
December	2	80.5	.05	.29	1.7	3.5	.41	32	31	2.6	22 (1)	.....	.....	.....	Distinct and strong.

* Up to the month of July, 1906, color was determined by means of the Lovibond tintometer; afterwards, by comparison with platinum cobalt standards. It was found, however, by means of parallel observations, that a simple computation would, with considerable accuracy, convert the Lovibond units into parts per million on the platinum scale. For the sake of easier comparison this has been done in the above table.

million U. S. gallons per acre per day. The experiments were arranged and supervised by the government analyst, Mr. J. B. Henderson, who reported favorably on the results obtained.

Records as to the removal of odors were, unfortunately, not made; to the best recollection of the writer it was not always quite complete, though very satisfactory reductions of organic matter and color were effected. The board, however, was evidently not thoroughly convinced by this report, probably owing to the suspicion with which the use of coagulants is, or was, regarded by British communities, and a further series of experiments was inaugurated, for the supervision of which the writer was employed by them.

The following were the principal methods of purification experimented with: A filter called by us the "Morry" filter, after its designer, Mr. C. A. Morry, an official of the Department of Public Works in Brisbane; a combination of sand filtration and the Morry filter; ordinary slow continuous sand filtration; the Anderson revolving purifier process; aëration and filtration of the bottom water from the reservoir; and slow intermittent sand filtration.

Several varieties of Morry filters were tested. The main principle of this filter is that of the Ducat bed for sewage treatment. The following description of a typical Morry filter will suffice to show the general arrangement. Other forms varied from this in the size of filtering material, and in some of them sand and even small coal were used.

The filter is constructed with walls of dry stonework within a timber frame on a square plan, and has an internal diameter of 9 ft. 4 in. at the bottom and 8 ft. 2 in. at the top.

The walls rest upon a concrete bed dished towards the sides, which forms the bottom of the filter and serves to conduct the effluent into a concrete channel which constitutes the discharge.

The filtering material consists of 6 ft. 6 in. in depth of screened gravel, a rough mechanical analysis of which gives:

100 per cent. finer than 8.5 millimeters.
51 " " " " 6.0 "
23 " " " " 4.0 "

TABLE 2.

MORRY FILTER NO. 1 (ALL GRAVEL).

Composition of Effluents. Monthly Average for 1906.

	Determinations.[1]	Rate Filtration U. S. Million Gals. per Acre Daily.	PARTS PER MILLION.										BACTERIA PER C.C. INCUBATED 48 HOURS.		Odor (Cold).
			AMMONIA.		Oxygen Consumed at 90° F.		Total Iron.	Free Carbonic Acid.	Nitrogen as Nitrates.	Color. (Platinum Scale.[2])	Dissolved Oxygen.	Turbidity. (All under 5 p.p.m. in Silica Scale.)	98° F. Neutral Agar.	68° F. Neutral Gelatine.	
			Free.	Albuminoid.	15 Minutes.	4 Hours.									
January	8	2.3	.02	.13	1.4	2.4	.09(7)	.....	.08	18	7.1 (4)	Slight.	57 (2)	.....	Fifty-seven determinations gave the following:
February	7	2.4	.01	.13	1.5	2.6	.12	.....	.10	20	8.0 (3)	,,	50 (1)	.....	
March	1	2.9	Tr.	.17	2.1	3.4	.14	.88	.03	36	.....	,,	.....	.....	
April	3	3.1	.02	.15	1.8	3.2	.15	1.2	.13	30	.....	,,	.....	.....	
May	3	2.9	.01	.13	1.6	3.0	.03	1.3	.08	34	.....	,,	.....	.....	Nil, 44
June	4	3.0	.02	.14	1.5	2.9	.03	1.2	.17	25	10.0	,,	.....	.....	Slt. tr., 4
July	5	2.6	.01	.17	1.5	2.8	.02	1.1	.09	23	10.2	,,	18 (2)	110 (1)	Trace, 9
August	4	2.3	.01	.17	1.3	2.5	.14	1.2	.10	18 (2)	9.7	,,	92 (2)	180 (2)	
September	2	2.4	.02	.18	1.3	2.5	.14	0.9	.15	20	.....	,,	50 (2)	.....	
October	5	2.8	.02	.16	1.2	2.1	.15	1.0 (4)	.17	13	8.8	Trace.	.....	.....	
November	4	2.5	.02	.16	1.1	2.3	.25	0.9	.07	13	8.7	,,	.....	.....	
December	1	2.9	.01	.17	1.0	2.0	.22	.....	.20	13	.....	,,	.....	.....	

[1] The figures in parentheses denote the number of determinations in the special cases.

[2] Except during the months of August and September, the color of this effluent was determined by the Lovibond tintometer. The figures given for the other months have been computed from the Lovibond units.

Water is fed on to the filter bed through an intermitter of 20 gal. capacity, from which it is discharged automatically by means of a siphon, at intervals, into the hopper of a revolving sprinkler which distributes it evenly over the bed, through which it slowly percolates. Provision is also made for side aëration, in addition to that derived from the loose stone walls, by means of four lines of loosely jointed unglazed earthenware pipes placed within the filtering material and traversing the bed from wall to wall. During the time this filter was at work, over six years, nothing was done to the filtering material except to rake the surface at long intervals in order to bring it to a level.

The color reduction effected by this filter (Table 2) was not good and odors occasionally appeared in the effluent. It is evident that the material of which the bed is composed was too coarse to permit of efficient filtration, but it was thought that a filter of this type might give good results if used as a roughing filter in conjunction with an ordinary continuous sand filter. This was duly tested. Very excellent results were obtained with the combination. It was found that odors and tastes were effectually removed when working

TABLE 3.

AVERAGE COMPOSITION OF EFFLUENTS FROM AND PERCENTAGE REDUCTION EFFECTED BY MORRY FILTER NO. 3A, USED AS A "ROUGHING FILTER."

	Fifty-Seven Determinations made during the Period 3d Oct. to 31st March, 1907. Average Rate of Filtration, 8.44 Million U. S. Gal. per Acre per Day.		Four Determinations made during the Period 1st to 24th April, 1907. Average Rate of Filtration, 17.8 Million U. S. Gal. per Acre per Day.	
	Parts per Million.	Per Cent. Reduction.	Parts per Million.	Per Cent. Reduction.
Free ammonia	.01	65	.01	73
Albuminoid ammonia	.20	30	.20	25
Oxygen consumed in 15 min.	1.7	18	1.2	15
Oxygen consumed in 4 hr.	3.0	21	2.4	17
Iron (total)	.23	38	.27	35
Dissolved oxygen	8.2	..	..	..
Turbidity	slight	..	slight trace	..
Color (platinum scale)*	25	39	15	42

*The figures for color were obtained by computation from Lovibond tintometer "units" estimated in the Lovibond tintometer.

at a combined rate of 6.0 million U. S. gallons per acre per twenty-four hours. The Morry filter used was similar in design to that already described, but the bed of the filter was only 3 ft. deep. The sand filter used contained 3 ft. of Brisbane River sand, having an effective size of 0.28 mm. and a uniformity coefficient of 1.96.

Tables 3 and 4 give the results obtained over an extended period.

Sixty-one observations of odor in the cold made during the above period gave the following:

Nil	14
Slight trace	12
Trace	7
Slight	19
Distinct	9

TABLE 4.

AVERAGE COMPOSITION OF EFFLUENTS FROM AND PERCENTAGE REDUCTION EFFECTED BY THE COMBINATION OF MORRY FILTER NO. 3A AND A SAND FILTER.

	THIRTY-EIGHT DETERMINATIONS DURING THE PERIOD MARCH, 1906, TO MARCH, 1907. AVERAGE RATE OF FILTRATION FOR THE COMBINATION, 2.93 MILLION U.S. GAL. PER ACRE PER DAY.		FOUR DETERMINATIONS MADE DURING THE PERIOD 1ST TO 24TH APRIL, 1907. AVERAGE RATE OF FILTRATION FOR THE COMBINATION, 6.0 MILLION U. S. GAL. PER ACRE PER DAY.	
	Parts per Million.	Per Cent. Reduction.	Parts per Million.	Per Cent. Reduction.
Free ammonia	.01	69	.01	76
Albuminoid ammonia	.12	54	.11	56
Oxygen consumed in 15 min.	1.3	31	1.0	27
Oxygen consumed in 4 hr.	2.3	34	2.0	33
Iron (total)	.12	68	.11	73
Dissolved oxygen	7.6	..	..	..
Turbidity	nil	..	nil	..
Color (platinum scale)*	13.0	54	9.0	70
Odor	nil	..	nil	..

*The figures for color were obtained by computation from Lovibond tintometer "units" estimated in the Lovibond tintometer.

Several sand filters of the ordinary slow continuous forms were tested. These, while giving very good and fairly uniform results, showed some slightly objectionable features and did not compare

favorably in their efficiency as regards removal of odors and tastes, with the combination of gravel bed and sand filter just mentioned, nor with the intermittent filter to be described later.

During the warmer months of the year, on account of the increased biological activity occasioned by higher temperatures, it was found that the oxygen dissolved in the water applied to the sand filters was often nearly and sometimes quite exhausted in passage through the sand bed. With the object of improving this condition aërators were fixed at the inlets to the sand filters. These aërators effected an almost complete saturation of the applied water in which the oxygen content was increased from about 75 per cent. to 98 per cent. of the possible amount.

Notwithstanding this, the oxygen still continued to be almost entirely exhausted in passage through the filters, though a slight increase in the oxygen content of the effluents did actually take place after installation of aërators at the inlets.

It seemed at first glance that this was unimportant as the aëration of purified water is a simple matter, but the writer was impressed with the fact that, as the using up of the oxygen indicates a corresponding oxidation of organic matter, which was the main object of our process, the fact that all oxygen was used up tended to show that greater oxidation might possibly be effected if more oxygen could be supplied to the bacteria doing the work. In the case of the Morry filters this was supplied by the method of application and the construction of the filter, and the effluents were never found lacking in dissolved oxygen; but these filters failed in other respects. These considerations led to the trial of intermittent sand beds.

It may be of interest to mention briefly the results of experiments with the Anderson Revolving Purifier Process which is successfully used for waters of this type in some British colonies. It is unnecessary to describe the process, which is well known and consists essentially in the solution of iron by the water, effected by passing it through a revolving drum which showers scrap iron continuously across the current, and the subsequent oxidation and precipitation of the iron. The ferric hydrate formed acts as a coagulant and the water is subsequently filtered. It was found

that under practicable conditions the process gave no results comparable with sand filtration *per se*, but that, when the iron dissolved in the purifier amounted to as much as 80 parts per million, the effluent produced by the filter working at a rate of over 6 million U. S. gallons per acre per day was of very exceptional quality, a removal of about 80 per cent. of organic matter expressed as albuminoid ammonia and oxygen consumed and about 90 per cent. of color being effected. This is a far better result than was obtained by any other process, but the method is, of course, quite impracticable on account of cost.

In January, 1907, it was suggested by Mr. Allen Hazen that aëration and filtration of the bottom water from the reservoir might give good results, and experiments in this connection were immediately undertaken. The bottom water for the greater portion of the year is, as a result of stagnation, very much more highly colored and contains much more organic matter and iron than the surface water. It was thought that, on account of the large amount of iron and the condition of the organic constituents, which is one of partial putrefaction, that the water after aëration and sedimentation would be readily amenable to the ordinary methods of filtration, and also that filtration, if combined with sedimentation, could be safely carried out at a far greater rate than usual on account of the presence of ferric hydrate in suspension, which would act as a coagulant much in the same manner as it does in the Anderson process just mentioned. It was found that, with liberal aëration and forty-eight hours' settlement previous to filtration, it was possible sometimes to get a very satisfactory filtrate and at a rate of 6 million U. S. gallons per acre per day, but the results were subject to considerable fluctuation and, usually, the filtrate contained considerable color and iron. It was found most difficult to secure a complete precipitation of iron hydrate, which was possibly suspended in a colloidal condition. The writer is by no means convinced, however, that, in the light of recent scientific research on the subject of the precipitation of colloids, this ingenious method of utilizing the coagulant provided by nature could not be successfully carried out.

One other process tried remains to be mentioned, namely, slow intermittent filtration through sand. The considerations which

led to the trial of this process have already been mentioned under the head of "continuous filters."

The principle is essentially the same as that used in the Morry gravel filters, the main differences being in the size of the filtering material used and in the mechanical details connected with the distribution of water over the filter bed.

It was expected that the additional oxygen supplied for the oxidation processes by the intermittent application of water to the sand bed would result in an increased oxidation of the dissolved organic matter with a more complete removal of iron, tastes, and odors. The results indicate that, through this method of operation, an increased amount of oxygen is undoubtedly supplied to the water in the sand bed, as the effluents always contained a considerable quantity. An increased oxidation of organic matter also takes place, though this is indeed quite slight.

The most satisfactory improvement is in the matter of removal of odors; this was most complete, as only on very rare occasions, even on warming, could the faintest odor be detected in the effluent from these filters, while it was always most palatable, the objectionable tastes of the reservoir water having been entirely removed.

The following are particulars of the construction of this filter, quoted from a report made by the writer to the board:

The tank containing the filter is made of 18-gauge corrugated galvanized iron, is 9 ft. 10 in. in diameter and 10 ft. deep, and has an effective area of 75.97 sq. ft. The underdrains consist of a brick arch composed of bricks loosely laid with very wide joints, extending across the middle of the tank to the outlet. This arch is covered with $1\frac{1}{2}$-in. gravel which is $1\frac{1}{2}$ in. deep at the sides of the tank away from the arch and rises in the center to just cover the bricks. Over this is placed 3 in. of $\frac{3}{4}$-in. gravel, then 2 in. of $\frac{1}{4}$-in. gravel, 2 in. of $\frac{1}{8}$-in. gravel, and 2 in. of coarse sand (effective size 4 mm.). The finished layer presents the same sloping appearance as the first gravel layer.

The filtering medium is composed of 3 ft. of sand obtained from the Enoggera Creek, having an effective size of 0.27 mm., 60 per cent. finer than 0.69 mm. and a uniformity coefficient of 2.5.

The water is led on to the filter through an iron pipe and falls

into an iron trough placed 2 in. above the surface of the sand. The trough is 12 in. wide and rests on baffle plates extending 6 in. on each side to effect an even distribution of the water. The exit is through a horizontal pipe level with the bottom of the tank.

The filter was started on the 21st of June, 1906, with a rest interval of four hours in twenty-four; between that date and the 7th of January, 1907, when the method of application was altered, raking to remove surface choking was necessary seven times. The average quantity per acre filtered between rakings was 70 million U. S. gallons and the rate of filtration averaged 2.8 million gallons per acre per day. From the 12th January until the 15th February, water was applied at intervals of one and one-half hours, 6 in. being delivered in three minutes at the commencement of each interval; this caused the filter to choke very rapidly. On the 16th February the interval of rest was increased to eight hours in twenty-four, and on the 19th Feburary the rate was increased to 6 million U. S. gallons per acre per twenty-four hours. The filter required raking on the 25th February and the 12th and 22d March; in July of the same year the records at hand show that the filter had been given no further raking and showed no signs of further choking. The results are shown in Table 5.

TABLE 5.

AVERAGE COMPOSITION OF EFFLUENTS FROM AND PERCENTAGE REDUCTION EFFECTED BY THE INTERMITTENT SAND FILTER.

	AVERAGE OF THIRTY-TWO DETERMINATIONS DURING THE PERIOD 21ST JUNE TO 19TH FEBRUARY, 1907. RATE OF FILTRATION, 2.8 MILLION GAL. PER ACRE PER DAY.		AVERAGE OF SIX DETERMINATIONS DURING THE PERIOD 20TH FEBRUARY, 1907, TO 24TH APRIL, 1907. RATE OF FILTRATION, 6.0 MILLION GAL. PER ACRE PER DAY.	
	Parts per Million.	Per Cent. Reduction.	Parts per Million.	Per Cent. Reduction.
Free ammonia	.01	70	.01	61
Albuminoid ammonia	.13	51	.12	49
Oxygen consumed in 15 min.	1.2	28	1.1	24
Oxygen consumed in 4 hr.	2.3	33	2.0	33
Iron (total)	.14	63	.12	62
Dissolved oxygen	7.3	..	7.8	..
Turbidity	nil	..	nil	..
Color (platinum scale)	11.7	55	7.3	63
Odor	nil	..	nil	..

A filter designed and operated in a somewhat similar manner and for a similar water was, I understand, in successful operation for some time at Springfield, Mass., and has been described by C. F. Story in the proceedings of this Association.*

In January, 1907, Mr. Allen Hazen visited Brisbane on behalf of the Brisbane Board of Water Works. In his report, which of course dealt with the whole question of the Brisbane water supply, he recommended, for the treatment of the Enoggera Reservoir water, the construction of a filter working intermittently, similar in design to the Ludlow filter at Springfield. Latest files of the Brisbane papers describe this filter as practically completed.

The work which has been described in this short résumé was performed almost entirely under the supervision of Mr. John Kemp, the board's chief engineer, to whom the writer is indebted for much advice.

The writer would also like to seize this opportunity of expressing his gratitude for the ever-ready and helpful advice given him in correspondence with Mr. Allen Hazen and his partner, Mr. G. C. Whipple, throughout the whole period over which these experiments were carried out.

DISCUSSION.

MR. ROBERT S. WESTON.† This Brisbane supply is an exaggerated Ludlow reservoir, and evidently required extreme treatment. There is so much organic matter and dissolved iron in the water that it becomes almost a sewage disposal problem rather than one of water purification. The problem has been solved here by giving the water an unusual dose of oxygen. I wondered, in reading over the paper, if Mr. Wasteneys had tried the distribution of the water on a sand filter continuously, by means of sprinklers, instead of using a period of application followed by a period of rest? This method, as all know, has proven most efficient for sewage disposal. One would think it might be worth while trying for the purification of a water containing as much organic matter and iron as does this Brisbane water.

*JOURNAL N. E. W. W. A., Vol. XXIII, p. 229.
†Sanitary Engineer, Boston, Mass.

I think the Association is very much indebted to Mr. Wasteneys for this very important contribution to our knowledge of the purification of waters which in our tropical country and in the southern states are coming more and more frequently into use. I remember an experience of my own in connection with the water supply of Henderson, N. C., which formed the subject of a paper,* read before this Association, at the meeting in Portsmouth in 1898, where I found huge growths of Bryozoa which obstructed the pipes and grew on the woodwork around the intake, and aggravated any nuisance due to the presence of algæ.

THE PRESIDENT. While waters of this type are more common in the South, we do have waters of this general character quite far North, although perhaps not as aggravated as in the South.

MR. ELBERT E. LOCHRIDGE.† Taking up one point that Mr. Weston brought up, the question of whether aëration on to a bed with a continuous filter would not accomplish the same result as an intermittent filter, I would like to say that in the experiments which we carried on at Ludlow we found that it was possible to get by aëration on to the beds on continuous filters a fairly good water, but that this was entirely a function of the rate. That is, if the rate was low enough to give a clear, low-colored water, with low organic content, the oxygen was entirely exhausted in the effluent, and accordingly we had that secondary odor which is very much more objectionable than the primary; while if the rate was higher, we could still get a fairly clear water, but not as effective as in the case of the lower rate and the higher resulting odor. While it was found that the water could be purified in that way, it was decided when the time came for the construction of the big plant that the additional oxygen, which could be secured by the intermittent action, was worth while.

On the question of the Ludlow water, I will state some of the later experiences in connection with this system, and a few thoughts on the whole question of growths in reservoirs. Up to the time of the construction of the filter at Ludlow, the water was uniformly bad nearly every year. Since that time it has reformed. I don't know just the cause, but the larger growths, such as weeds, sprouts,

* JOURNAL N. E. W. W. A., Vol. XIII, p. 20.
† Chief Engineer, Springfield Water Department.

and even trees, in the shallow water, have been cleaned up, the reservoir has been raised in the last year or two, and it has been kept somewhat fuller, so that this year there has not been a thing about that water which could be objected to. There is even another town now clamoring for the use of it, specifying that they want it, and the town of Ludlow has been using it without any objection at all through this entire summer. Of course we cannot guarantee it for years to come, but it shows that even with a very hot summer it may be possible in some of these reservoirs, by deepening them or changing the conditions in some way, to avoid the troubles which have heretofore been experienced.

As to filtration and later aëration, there is no question that the aëration which follows the filtration is of a great help in improving the water, particularly in the reduction of what we have always termed the secondary odors, which are entirely distinct from the odors of the organism itself, and which seem to be caused by some by-products in the oxidization of the organic matter.

THE PRESIDENT. As I saw these various processes in use experimentally at Enoggera, there were several of them which, if they had been operated by themselves, effected so great an improvement in the water that any one would have thought the processes remarkably successful, but the process involving intermittent filtration, either as last carried out or with the Morry filter, which was simply an intermittent filtration followed by sand filtration, always produced an effluent which was so much more attractive in appearance and taste and odor than the effluents of the other processes, that, seeing them all there side by side, there was no hesitation in selecting it as the one best adapted to the existing conditions. I think that explanation is a very proper one. The other processes did improve the water tremendously; and if considered by themselves might have been thought very creditable and possibly sufficient. This is a type of water which has been little studied in the past, and I feel that it is a type that we shall have to study a great deal more in the future.

MR. FRANCIS T. KEMBLE. Mr. President, can you tell me with regard to the deterioration of water after being filtered, as compared with the way water keeps in its natural condition?

THE PRESIDENT. I will answer in regard to Brisbane, and what

I say applies in general to other cases, according to circumstances and variations. It is absolutely impossible to store filtered water in the climate of Brisbane in an open reservoir without having it go to pieces and destroy the effect of the filtration. The only way is to have covered reservoirs for filtered water.

This is largely true here also, but there are places in the North where the summer temperatures are low, and where the water is used so rapidly that covered reservoirs are not needed. Mr. Cook has a case over in Paterson where open reservoirs have been used without any serious trouble, at least from organic growths.

MR. GEORGE C. WHIPPLE* (*by letter*). Mr. Wasteneys' paper is a valuable addition to the literature of water filtration experiments. It is all the more valuable to us because the methods of analysis used have been those of the American Public Health Association. It is gratifying to those who spent so much time in preparing these methods to find that they have been of service in other countries as well as in the United States. It is interesting, also, to find that the waters of Australia are troubled with the same pests that are so common in surface water supplies in this country. In this respect, as in many other things, Australia is more closely allied to the United States than it is to Old England.

Most of the studies of algæ have been made thus far in comparatively cold climates where the changes between summer and winter are of considerable magnitude. Here is an instance, however, where the conditions of temperature, light, etc., are more constant and severe throughout the year, and it is not surprising, therefore, that the algæ growths should be greater than those with which we are familiar. It would have been interesting if the author had included in his paper some detailed results of his microscopical examinations.

The author speaks of transforming the color determinations obtained by the Lovibond tintometer to the platinum standard by means of a simple computation. It would be convenient if this method of computation were stated, as it might be useful to others in comparing data obtained by the use of this instrument. In looking over the table of analyses of the Enoggera Reservoir (Table 1) it is noted that the color of the water from January

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to July was always above 40, but that from August to December the colors ranged from 22 to 32. Inasmuch as this change in color corresponds with the change in the use of the tintometer, the question arises as to whether the former was due to an actual change in the character of the water or to differences in the method of measurement used.

The construction of the Enoggera filter is of interest for another reason, namely, that it is designed solely for the purpose of obtaining a supply of clean water. Here is a case where the water supply is taken from a practically uninhabited watershed and yet filtration is deemed necessary. This is in line with modern progress. American engineers are learning that in spite of the stripping of the soil from reservoir sites, the drainage of swamps, the use of copper sulphate, etc., the algæ problem still remains with us. We are coming to believe that it is better, and in the end cheaper, all things considered, to solve this problem by the filtration of the water rather than to resort to any of the halfway measures, useful though they may be as temporary expedients. In designing water filters for this service the great thing to be always remembered is that plenty of oxygen must be provided. Aëration is destined to play an important part in water purification where the problem of algæ removal is involved.

Mr. Hardolph Wasteneys (*by letter*). With reference to the point raised by Mr. Weston as to application by continuous sprinkling as in sewage treatment I would like to point out that this, in effect, was tried at Enoggera with the slow sand filters, where aërators, as mentioned in the paper, were placed at the inlets to the filters and complete saturation of the applied water was obtained. There was the difference, however, that the sand surface was kept submerged. Our results were similar, under these circumstances, to those mentioned by Mr. Lochridge as having been obtained at Ludlow. We did not, however, try continuous sprinkling on to the exposed sand surface.

In reply to Mr. Whipple's remarks I regret that I have not at hand any records of biological analyses of the Enoggera water made during the period under review. As regards the method of computation employed to convert the units of the Lovibond tintometer to parts per million on the platinum scale: The method

used was to multiply the number of units of yellow on the Lovibond scale by 9. This gives a figure which approximates very closely to observed values on the platinum scale as indicated by a large number of parallel observations, though when the colors are very high, i. e., over 60 on the platinum scale, the comparison is less accurate. The high color observed for the month of May, 1906, is due to the annual overturning of the reservoir contents which takes place usually during that month. I must confess that the sudden drop in the color figures during the period August to December, coincident with the use of another method of determination, looks significant. It was, however, undoubtedly due to the change in color of the water, as, even after the institution of platinum cobalt standards, the use of the Lovibond standards was continued and the figures show a corresponding decrease in yellow units.

During the months May, 1904, to January, 1905, estimations of color were made in the standard color tubes with glasses graded to indicate parts per million of platinum according to the United States Geological Survey method. The following figures then obtained may be interesting to compare with the figures quoted in my paper for the same months of 1906. It will be seen that they are (with the exceptions of May and January) almost identical.

MONTHLY AVERAGES OF WEEKLY DETERMINATIONS OF COLOR.

Month.	Color, Platinum Scale.
1904.	
May	50
June	52
July	41
August	37
September	32
October	32
November	21
December	21
1905.	
January	20

HAS THE TIME COME FOR DOUBLE MUNICIPAL WATER SUPPLIES, ONE — NATURALLY PURE — FOR DRINKING AND COOKING, THE OTHER — DENATURIZED OR STERILIZED — FOR ALL OTHER PURPOSES?

BY W. T. SEDGWICK AND H. P. LETTON.

(From the Sanitary Research Laboratories of the Department of Biology and Public Health, Massachusetts Institute of Technology, Boston.)

[*Read November 8, 1911.*]

It has often been proposed that two water supplies be provided for cities, one to furnish water of the highest quality for drinking and cooking, and another for all other purposes. The advantages of this plan were recognized as far back as the time of the Romans. Frontinus,[1] writing in A.D. 97 concerning the water supply of the city of Rome, states that the water from one aqueduct was used exclusively for drinking and cooking purposes, that from another aqueduct for baths, and that from others only for irrigation. In modern times the question has also been seriously considered, Brackett [2] having made a report to the Metropolitan Water Board in 1895 on a separate supply for the city of Boston. The subject has also been discussed in a more general way by Axtell,[3] McElroy,[4] and others.

Our large cities with but few exceptions obtain their water supply from rivers, lakes, or large artificial storage reservoirs. These sources are in some cases grossly polluted, and many that are not polluted at present are in constant danger of becoming so, notwithstanding the fact that elaborate precautions are taken to guard against contamination. In case the present supply is polluted, the city will generally be compelled, sooner or later, to go to the expense of constructing a filtration system or of obtaining a new supply from a more distant, non-polluted source. Cities having as a source of supply lakes or artificial reservoirs must maintain a constant and efficient oversight of the watershed in order to guard against pollution. Moreover, no matter how complete and efficient the system of filtration or the supervision of the

watershed, these provisions are not always infallible as safeguards. This is shown by the typhoid fever epidemics at Lawrence, Mass., and elsewhere, due to trouble with the filters, and those at New Haven, Conn.; Scranton, Pa.; Plymouth, Pa.; and many other places, due to pollution of the watersheds feeding the storage reservoirs.

We are at present in a peculiar position — namely, when most of the water supplied to our modern communities is not used either for drinking or for cooking, and yet, since any of it may at any time be used for these purposes, all of the huge streams that pour through our cities are expected to be, from the sanitary standpoint, above suspicion. Thus far we have got on fairly well under this arrangement, but the time will probably come when the amounts so required will become so vast, and so costly to keep up to the required purity, that we shall be driven to double supplies, one for drinking and cooking, the other for all other purposes.

Even if it be granted, however, that with proper precautions the danger to the public health from ordinary water supplies is small, the question still deserves to be considered whether from a sentimental or esthetic standpoint the time has not come for double municipal supplies.

For it is an open secret that many persons dwelling in cities provided with filtered water supplies derived from polluted sources cheerfully purchase spring or other waters which they believe to be naturally pure rather than drink the purified waters which are known to come from sewage-laden sources. It must be admitted, moreover, that it is by no means agreeable to dwell in detail upon the proximate sources of some of our most reputable water supplies, derived as these often are more or less directly from streams laden with human excrements or with street washings, the drainage of slaughter houses, of hospitals, and the like. Some years ago we were grateful for even a moderate degree of cleanness, but our standards in these matters are constantly rising, and decency is everywhere more and more being added to health as a consideration of importance in public affairs. Again, many filtered waters are at times colored or turbid, or have a disagreeable taste or odor, due to the presence of organic matter not removed by the filters, although the bacterial efficiency of the latter may be high. Water

obtained from impounding reservoirs is also often colored, and of a marked taste or odor, due to the growth of microscopic organisms. The New York and the Boston supplies are examples of this type. In order to prevent such growths the reservoir is sometimes during construction, at great expense, completely stripped of the top layer of soil; and even then the result may be only partially successful. Again, a water from a surface supply is frequently quite warm during the summer months and correspondingly less potable than a ground water with a fairly constant temperature all the year round.

The average daily per capita consumption of water in cities of the United States, with a population of 100 000 or more, is about 115 gallons, and of this amount Brackett [5] has shown that not over 35 gallons are used for domestic purposes, while the amount actually used for drinking and culinary purposes is less than 3 gallons. If, however, we allow 10 gallons per capita per day and consider the fact that this would only be 1 000 000 gallons per day for a city of 100 000 population, we see at once that it would be possible in practically every case to obtain a sufficient supply of ground water that would be purer and more potable than most surface waters, even if these last are filtered.

We are in the midst of a mighty sanitary awakening, and are spending millions of dollars every year in protecting and purifying our water supplies, yet of all the water distributed probably less than three per cent. actually concerns the public health. With this fact in mind it is evident that we seem to be following an uneconomical course, and that any plan for betterment should be thoroughly investigated.

Heretofore, whenever the question of a double supply has been proposed, the one insurmountable objection has been that it would be impossible to prevent people from drinking from the second and impure supply. This was clearly shown at Lawrence, Mass., in 1893. The city used a filtered supply from the Merrimac River, while in some of the mills the raw river water which was badly polluted with sewage was used for washing. During the year there were nine deaths from typhoid fever of mill operatives who had drunk the river water notwithstanding the fact that they had been

fully warned of the danger, while the total number of deaths from typhoid in the entire city was only seventeen.

In order to make the double system practicable it is necessary (1) *to so regulate the use of the smaller supply that it shall not be wasted*, and (2) *to so treat the larger supply that it shall not under any circumstances be used for drinking.*

The first condition could be attained by making the cost of the water such that its value would be appreciated, and by metering all services. It is the second condition, or that of *denaturizing* or *sterilizing* the supply, so to speak, that is the main object of consideration in the present paper.

In recent years there has come into general use an agent which it is believed will be a satisfactory *denaturizer*, both from a sanitary and an economic standpoint. This substance is calcium hypochlorite [$Ca(OCl)_2$], which is being extensively employed as a sterilizer for water and sewage. Its especial fitness for the case under discussion lies in the fact that if put into a water in such quantity that it is not all decomposed, it imparts to the water an odor and a taste that are very disagreeable. With a water thus treated its use for drinking would be very rare, and even if it were so used no harmful results would follow, as the water would be practically sterile and as a little undecomposed hypochlorite is probably not detrimental to health. Brackett has shown[5] that about ninety per cent. of the water used for domestic purposes is employed in flushing water-closets, in wash tubs, in bath tubs, and in sinks and bowls. The addition of the hypochlorite would not affect the use of the water for any of the above purposes if we except the small amount used for drinking and cooking. From the same authority it appears that of the water used for commercial purposes the larger portion is employed in steam railroads, factories, elevators, power plants, and office buildings. The hypochlorite would affect the use of the water in very few, if any, of the above cases. It is also quite evident that it would not affect the public use of the water for such purposes as street sprinkling, ornamental fountains, sewer flushing, and fires, but would instead be a benefit on account of its disinfecting action.

From a consideration of all the above facts, it appears that as a sanitary measure the plan is highly commendable. To determine

whether it is economically practicable is a much harder problem, as this will be established largely by local conditions. It would, of course, be necessary to install a separate distribution system, and, although this would be of much smaller piping than the present one, it would still be the large item of expense. Separate services and meters would also be required, which would be another large item. These, however, are points which would have to be considered as special problems in each individual case.

The object of this paper is merely to present the plan as it stands to-day to water-works officials, engineers, and sanitarians, in the belief that it is a new aspect of an old problem, and one that can be, and will be, profitably applied in some cases in the near future.

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[2] Brackett. Water Supply of Different Qualities for Different Purposes. Report Massachusetts State Board of Health on Metropolitan Water Supply, 1895, p. 217.
[3] Axtell. Pure Water for Drinking and Cooking. *Eng. Mag.*, 1896, xi, p. 67.
[4] McElroy. City Water Supplies of the Future. *Eng. Mag.*, 1894, vi, p. 821.
[5] Brackett. Consumption and Waste of Water. Am. Soc. C. E., 1895, xxxiv, p. 185.

DISCUSSION.

MR. CHARLES W. SHERMAN. The paper certainly presents a very interesting possibility, and there can be no question from an engineering point of view that it would be practicable. The only question, as it occurs to me, is the economic one, which the authors have already called attention to. It would unquestionably mean an expensive water supply to furnish a double supply in this way. It is perfectly conceivable that there may be cases where that expense would be warranted.

THE PRESIDENT. Will Mr. Weston say something as to the probable effect of an excess of chlorine on the pipes and other water-works fixtures?

Mr. ROBERT S. WESTON. Mr. President, I was just about to ask the author of the paper that question. I wondered if that would not be an objection. I should think the addition of chlorine would make the water more corrosive than it was before; whether it would be appreciably more so or not, I could not say.

MR. ARTHUR N. FRENCH. You may be interested to know that

we are using chloride of lime (about six pounds per million gallons) at Hyde Park. I do not know that there is any other place in Massachusetts that is doing it. We have been using it for about a year, and I cannot see that there is any effect upon the water that is disagreeable. People drink it and do not make any objection to it. Our water is well water, and it is fairly clear and does not carry very much sediment. We began to use it because we had a typhoid-fever scare last year, there were several deaths, and we started the use of it as a matter of safety. The State Board of Health have knowledge of it, and have been out to investigate it, but they have neither approved nor disapproved. I cannot see that it corrodes the pipes any more than the plain water did. It corrodes the implements that we use in mixing up the solution very badly. Wooden pails will last only a very short time, and galvanized iron is eaten out fairly quick. Our plant is only a temporary one, for we expect to take the Metropolitan water now in a short time, so that we have not put in anything permanent.

THE PRESIDENT. If you will try using sixteen pounds for a day or two instead of six, you may get some new light on the smell question.

MR. FRENCH. Of course that would make a difference.

PROF. E. B. PHELPS. Mr. Sherman's remarks as to the expensiveness of this plan seem to me not to be of general application. One can easily conceive a situation in which a town is face to face with the proposition of going quite a distance and at considerable expense for a new supply of sufficient magnitude and proper quality for all purposes. Now if there be near at hand a supply of ample magnitude, although of inferior quality, it might not be necessary to go so far afield for the small pure supply, and it seems to me in such a case this plan might easily work out a real economy.

In regard to the question of corrosive action, I can state that I have had under my personal observation three installations in which water is pumped which has been previously treated with hypochlorite. I have had special notice taken of the interiors of the pumps from time to time and there has been thus far not the slightest sign of any injurious action. One of these plants has been in operation for about ten months and the water is receiving

hypochlorite in the proportion of about 7½ lb. per million gallons, and the others have been in operation for eleven months and two years respectively, the hypochlorite averaging about 8 lb. and running as high as 12 on occasions. Furthermore, in none of these cases, nor of several others which I have had under my immediate observation for some time, have there been any unusual complaints from or indications of corrosion in the pipes. A careful study of the chemical principles involved has led me to believe that the action of this extremely dilute and slightly alkaline solution is protective rather than otherwise, a conclusion which I think is amply justified in the results. In a concentrated form in which the solution itself is handled it is quite true that the slight protection due to the alkalinity is more than offset by the corrosive properties of the free hypochlorous acid liberated.

Mr. Randolph Bainbridge. I might say that in the city of Quincy at the present time the Fore River Shipbuilding Company uses about half a million gallons of water a day, and having found it expensive to buy Metropolitan water, has a double supply with a reservoir of its own. All fixtures connected therewith are labeled "Industrial Water." As far as I can find out from observation, from what my men tell me, and from what the men at the plant say, there is absolutely no trouble whatever with anybody using the wrong water.

In this connection I might say that this water is not treated in any way whatever. It is simply that the water from the reservoir, which is, as has been described, street water, and water from fields and barnyards, and so on, is used solely for industrial purposes, the Metropolitan supply is considered good enough for anybody to drink. Last winter the company wanted to enlarge the plant to about a million gallons a day, and use the old Quincy reservoir, and in fact entered into a contract with the city to do so. We found, after we had made a contract, that the state would want the city to pay them three times what we could get from the company. In other words, we have a reservoir that is good for a million or a million and a half a day, and which would answer the very purpose we have been speaking of, a secondary supply, but we have to pay the state for the privilege of using it about twice what we can get for the water.

But there is no question whatever but what this thing is coming. The farmer, the granite man, and the manufacturer at the present time do not get a square show at the water. What you have to charge in any water-works system, whether 20 cents or 15 cents or 10 cents a thousand gallons, is practically robbing the manufacturer, and I do not suppose that this shows up in any other city plainer than it does in Quincy. Lots of our people use well water for boilers, but that makes work for the boiler men. As has been said, about 5 gal. a day of pure water is enough for practically all that a secondary supply would be needed for, and large local supplies would thus be available for industrial purposes.

MR. FRANK C. KIMBALL. That the time is coming when some conservation of potable water will have to be made, I think is beyond question. Whether a double supply can be put in at an expense which will pay from the present standpoint of proper charges for water is a question. If, as Mr. Bainbridge has suggested, a charge of ten cents a thousand gallons is too high for water for such uses as he mentions I doubt if the time will come very soon when even industrial water can be treated in such manner that it cannot be used for domestic purposes, and at the same time not so radically treated that it will not be offensive for other purposes, at much less price than that, separate distribution and pumping also being considered. I am speaking now, of course, of municipal supplies as a whole. This is a subject, however, that I think it is very pertinent for an association like this to consider, and sooner or later the problem of a double supply of water will have to be worked out for some communities, although it will probably be a long time before it is necessary for the majority of them to take up this question.

MR. JOHN H. COOK. Mr. President, this matter is, like the tariff, a local question. There may be times when it will pay, and there will be other times when it will not pay. It seems to me every situation would have to be judged by itself. So far as treating the water successfully without making it offensive goes, I think that it generally can be done without trouble. We have treated some 40 million gallons a day for the people of Jersey City, as is doubtless well known to many gentlemen here, for some time, and without any complaints whatever from the people who have used

the water. The treatment is extremely inexpensive, and I should suppose that with most waters it would be perfectly satisfactory, except to a man who knew it and did not like the idea of it. My idea is that it will be a long time before a double supply is generally introduced in our communities. We have a great many mills that are supplied, or were supplied formerly, with two separate systems, one system for toilet purposes and another for drinking, but that was never a very successful proposition. The employees insisted on drinking the wrong water, although the taps were all labeled with brass tags which said, "Do not drink this water," or, "This water for drinking purposes." The help would drink indifferently and we did not find it at all successful.

MR. SHERMAN. Mr. Phelps's question suggests that possibly I might amplify my previous remarks a little, with regard to the expense of the proposition, and bring out more clearly the point which I especially had in mind. I do not doubt that the distribution system and the supply works could be put in in many cases at a cost which might be feasible; but when it came to a duplication of the plumbing, I think the householder would feel it very seriously, unless it was in the comparatively rare case where he is willing to pay twenty dollars or thirty dollars a year for spring water in addition to the ordinary house supply. In cases like that he might be willing to stand the double plumbing expense.

THE PRESIDENT. I think the double plumbing is a very important question. I would like to know what the plumbing in a city costs as compared with the water supply. It is my impression that in Boston the plumbing costs more than the Metropolitan Water Works. Does anybody know about that?

MR. GEORGE A. CALDWELL. The cost of the plumbing for a separate supply for drinking purposes only would not be a serious matter. For an ordinary twelve-room house with, say, four outlets for drinking water only, the cost of the extra piping, using brass pipe, not including the meter or the service from the main to the house, would not exceed $50, including all labor and material for the work. In many cases the cost would not exceed $25, and I believe the average cost based on a twelve-room house with four outlets would be about $35.

MR. JOHN C. CHASE. It strikes me that the installing of two separate sources of supply in an ordinary community would be a very serious proposition to consider. I can see only one way in which it would be practicable, and that is that the residence portion should be supplied with pure water, and the business and manufacturing sections with the second quality for commercial purposes so arranged that none of it could be used for drinking purposes. Moreover, the ordinary dwelling house would not use such a great amount that it would be necessary to supply it with a secondary supply; and in the manufacturing sections, I think it would not be a very difficult matter to arrange for the use of a water that is not up to the required standard for domestic uses, segregating it to such an extent that there would be no danger of using it for drinking purposes.

I have in mind a case in Haverhill, Mass., where typhoid fever appeared in one of the factories a few years ago, and, if I remember right, it was found that the help instead of using the city water were drinking from a nearby faucet which was supplied with impure river water. I think it would be utterly impracticable to put two kinds of water into a place where there is a chance of the undesirable one being used. My experience with the average workman is that he will take what is handiest.

THE PRESIDENT. I remember that this system was used some years ago, though perhaps not fully, at Augusta, Me., when the main supply at that time was taken from the Kennebec River, and a spring-water supply was piped throughout the city and into nearly all residences, and was sold separately. This was known as the "Devine Spring Water." I was much interested in that when I first heard of it, but I found that the name came simply from a Frenchman on whose farm the spring was located. Afterward Augusta secured a new supply of excellent quality and the Devine spring fell into disrepute.

PROFESSOR SEDGWICK. *Mr. President and friends,* — I want to begin by saying how glad I am to be here again and to see the faces of so many old friends, and of those who would, I am sure, be new friends if I were fortunate enough to be able to attend more of your meetings. It has been a real regret to me that for the last few years I have been able to be present so seldom. But I am sure

since I see so many of the old officers are still on deck, and so many of the old members still present, that the Association lives up to its old traditions. And it was with that feeling that Mr. Letton and I brought this paper here to-day.

In a discussion before one of our classes, last year, concerning the use of calcium hypochlorite for the treatment of water, a use to which this material is already being put for one purpose and another, Mr. Letton used the happy term *denaturizing* the water; whereupon I asked him to work up this subject of a double supply and bring it up to date. I remembered Mr. Brackett's old paper, and I have long been impressed, as, of course, everybody has, with the fact that while most of the water that we have in our cities is not used for drinking or cooking, all of it has to be fit to drink or for cooking, — a condition which is certainly anomalous, and which in certain cases and under certain conditions leads us to inquire whether we cannot do something about it.

There is another side of the subject which appeals to me very much as a sanitarian, and has long done so, and that is this: What I call the sentimental objection to a water which is hardly more than filtered dilute sewage. Now, I would not for a moment go back on filtration; let that be distinctly understood. The introduction of filtration has been one of the greatest blessings that ever befell the community or the water-works profession. At the same time, there is no doubt that it is not a pleasant thing to sit down and reflect, if one must do so, that the particular drinking water which comes to his table, or into his kitchen, and is used for cooking and drinking, is separated from dilute sewage, in which you can see fecal matters, by a little layer of sand only a few feet thick. The origin of drinking water is important, and that is recognized by all filtration men. The purer the raw water, the higher the grade of it, the better. There are communities, and I could name some of them, where the water supply is hardly more, from one point of view and stating it in its worst way, than filtered dilute sewage. And it is a great comfort to be able to know that we can filter a highly sewage-polluted stream in such a way as to make it powerless to injure the public health. At the same time, it is not always a pleasant thing to stop and think of what went into the water just before it was filtered, or what was in

it at the time. There are communities that would gladly pay a good deal if they could get a pure upland water rather than have filtered water derived from a source of the sort to which they must now go.

With those thoughts in mind, and recognizing, as I must as a sanitarian, the fact that our standards are constantly rising, and that decency is everywhere to-day being linked up with hygiene and sanitation, original cleanliness getting an increased value all the time, it seemed to me worth while for Mr. Letton to work out this matter, and I took up the subject afterwards with him with a good deal of interest.

Now, to begin with, when we have two kinds of public water supply, one of which is good and one of which is bad, there is absolutely no insurance against the use of the bad supply by careless people. That idea has been emphasized sufficiently already, and it is a well-known fact that there are plenty of people in a community who, if a water looks fairly well and tastes fairly well, will drink it even if there is a sign right over the tap from which they draw it saying that the water is not fit to drink I remember seeing that illustrated in Lowell and in Lawrence, and I remember seeing it in Italy, where they had the same sign (*aqua non potabile*) over some of their waters that are not supposed to be used for drinking. Of course you may say that that is of no consequence except to the man who disobeys the rule; but it is of great consequence to the community, because every case of typhoid fever or other infectious disease arising in a community, even in a person of no particular consequence *per se*, is of great importance, or may be of great importance, to the community. Every such case is a nest or a focus of disease from which disease may spread. If, for example, it is a careless workman who comes down himself with typhoid fever, you may say, "Well, he is simply paying the penalty for his carelessness." But if that man has typhoid fever in his home, and his sister, or his sister's daughter, or his own daughter, happens to be a servant in your kitchen or mine, or in your nursery, and brings the germs of the disease to your house or to mine, it then becomes a matter of serious importance to the whole community. "We are all members one of another" nowadays even more than in ancient days, and getting more and more so as

population thickens. So that, even in the case supposed, it is not merely the penalty the man pays who drinks the wrong water; it may be the penalty which the community pays for having the bad water accessible for drinking.

This has been and always will be the objection to two supplies, one good and one bad and infected with the germs of disease. But this plan of denaturizing the water removes that objection. The proposition is simply to treat the inferior water in such a way that if it should be used for drinking, for which it is not expected to be used, no harm will result, unless it be a bad taste in the mouth, possibly, if the denaturization is strong enough for that. At any rate, the water by the denaturizing agent used will itself be made practically sterile. And in that connection I may say that it is not necessary to so overload the water with the hypochlorite that it shall have a bad odor or taste, although on some accounts it would be well to do that. It is sufficient if enough be added to sterilize the water, and that can be done judiciously, as has been shown in many communities, without producing a bad taste or smell. It is not, then, a question between a bad smelling and bad tasting water and a good water; it is a question between two kinds of safe water, one derived from sources naturally pure and above objection on the score of sewage origin; the other, not standing in that category, but coming from objectionable sources.

The whole object of the paper, however, is merely to emphasize the fact that we now have in our possession a material by which we can, if we want to, denaturize any water, and more than once this method has been used in emergencies. When, for example, a typhoid fever epidemic has broken out, as in Torrington, Conn., lately, and it was necessary to do something immediately to the water, a quick disinfecting plant with this same hypochlorite was introduced, as has been done in several similar instances, and the water going to everybody has been denaturized for a time. In the state of Kansas I noticed the other day, in the report of the State Board of Health, they keep, so to speak, a "wrecking train" ready; that is to say, they keep an emergency hypochlorite plant on wheels ready to run off to any town in the state that has a typhoid-fever epidemic due to the pollution of its water supply. That would be a good plan in any state where the water supplies are

seriously open to suspicion. It is, in fact, done in more places, I fancy, than is commonly reported. The wise State Board of Health will everywhere have in its engineering department, if it suspects the likelihood of any such need, some such plant always ready for energencies. This, as I have said, was the main point, to bring the matter up here for discussion.

On the economical side, we realize, of course, that cities that are already provided with good water supplies would never think of embarking on this scheme; neither would those cities which can get abundant water think of doing anything of the kind. It will only be in some special, peculiar situations, where water from a good source cannot be obtained in sufficient quantity, except at an almost prohibitive expense, or where for some local or peculiar reasons it may be desirable to have two systems of supply. But it seemed to me, and I think the discussion has justified the belief, that an Association like this, that is always anxious to know whatever good is going on, and whatever is possible under new or trying conditions, might take this up and discuss it with advantage; and I am sure that both Mr. Letton and I are well satisfied with the discussion that has taken place. It has brought out exactly the objections which might have been anticipated, and a rather surprising amount of concurrence with our general contention, which is simply this: That we have here a new agent, useful under certain circumstances, the whole thing being, as Mr. Letton said, simply a new aspect of an old problem.

SOME NOTES ON TROPICAL WATER SUPPLY AND A STUDY OF FILTRATION AT PANAMA.

BY HERMAN K. HIGGINS.

[*Read November 8, 1911.*]

One may find in the history of a frontier community a condensed compendium of the history of the race, the swiftness of which is perhaps well exemplified by the moving pictures we sometimes see, showing us, in a fraction of the time really consumed, such a scene as a vessel traveling in a lock, bobbing back and forth with no apparent reason, the men on the bank running and jumping with expressions of entire leisure. The view so presented is likely to seem in the retrospect more amusing than historical.

The history of Panama water supply, of which general subject filtration is one of the lesser phases, certainly seems from this distance amusing enough, but was, in the enacting, fraught with trials and tribulations. A short historical sketch from the standpoint of an interested spectator and innocent participant may serve to introduce the subject.

> It was in the gray November,
> Well the morn do I remember;
> Dark and angry clouds hung lowering,
> And the tropic rain came pouring,
> As it oft had poured before,

might from several standpoints be considered a fit setting for the picture. Mackintosh and umbrella were checked a mile away.

The writer sought for a cooling drink; he did not like to patronize a saloon, but he finally found that it was the only place in which anything to drink could be had for love or money. The fluid served was bad, but not so bad as nothing.

Tropical Colon and Panama had for many years provided for themselves and visitors a limited supply of alleged-to-be-potable water, more often an infusion of wrigglers and nameless impurities. This water in a state of comparative purity was deposited by the

TANK CAR ON PANAMA RAILROAD, 1906.

too willing skies on the spreading roofs, where, like the unclean spirit in holy writ, it immediately proceeded to take to itself seven — rather seventy and seven — forms of available dirt deposited on said roofs largely from the claws, beaks, and plumage of numerous scavenging buzzards, and at rarer intervals by dust-laden winds. The roofs are mostly steep, whereby the descending flood readily bore its burden to cisterns, or, oftener, to a battery of barrels usually open to further contamination. Some of the more wealthy and intelligent of the natives ran the stored water through a porous earthen filter which removed much of the dirt and, incidentally, or *vice versa*, cooled the water several degrees. Fortunate was the man who had his cistern deep and his barrels well filled. During the dry season his less provident neighbors often retired with a thirst such as Kipling could only find "East of Suez." He never experienced "East of Colon" or he would have said that.

Panama City is said to have had a limited number of wells, of which perhaps the less said the better; they had been filled up, for the most part at least, before the writer visited the city.

Colon, built on a coral reef, had plenty of ground water, but it was too thick to be potable. Unlike the Missouri and Mississippi water, which one to the manor born stirs and drinks quickly, the Colon ground water is so very rich that no amount of stirring would render it drinkable; it might more easily have been rendered eatable.

Thus it was that Colon must depend on rain entirely. Fortunately, the rainfall at Colon covers the dry season fairly well, and only occasionally was there a lack of stored water.

With the development of the Panama Railroad, water supply conditions improved. Water was required at Colon for boilers, hotels, ships, and the like, so a small reservoir was constructed, pumps were installed, pipes laid, and the march of improvement started in earnest. Any deficiencies in storage or rainfall were corrected by the use of tank cars, of which the Panama Railroad had a large number, bringing water from inland rivers such as the Frijoles (Beans) River, which the writer was told never failed, delivering it to the suction main of the railroad company's pumping station (Plate I). The discharge line of these pumps was connected to a high tank in the railway yard, also to the houses occu-

pied by railway officials, consuls, the hospitals, and a few other favored premises, including, by no means least in importance, two water stations some half mile apart (Plate III, Fig. 1), at which daily a long line of the unwashed could be seen with receptacles of all sorts awaiting each his or her turn to enter and for a certain fee draw his day's supply. How much of the fee finally reached the railroad company, deponent could not satisfy himself; the police agent collectors were under very little check.

This phase of the supply lasted till the French Canal Company built the breakwater and on it founded the town of Cristobal. The railway company's supply was limited and the canal company needed water. Judging by published accounts, it was not applied solely to floating equipment or live stock.

The earlier water supply equipment seems to have been quite limited in capacity and extent, the French town was small, water from across the bay was supplied to the De Lesseps houses, to the shops and wharves, and to a centrally located fountain, now no longer extant, from which monsieur drew his daily ration, as did the writer at a later date.

The supply from which monsieur's water was derived was five miles away across Limon Bay. Never-failing springs filled a reservoir from which tank vessels were supplied. These in turn formed the suction wells from which local pumps delivered the water to the town fountain, shops, etc.

At about the beginning of the American régime, a small dam was built across a section of the diversion channel, pumps and pipe line installed, iron tanks were set upon a convenient hill, water was piped well over the town of Cristobal, and soon after practically all the houses were supplied from this local system. The works were, for their capacity, well designed, well built, and, barring certain administrative difficulties, the system gave a very good account of itself. It was of course not always working, as the pipes were laid in loose fill and breaks were frequent. The attendants were negroes who considered the whole thing witchcraft and the plant under the personal control of the devil. It naturally followed that any trouble in the night watches, a leaking plunger, rattling valve, or any unusual sound or sight, put the attendant in a panic. If he was brave, he banked the fires before he ran.

This was true of most of the night firemen. Fortunately the French régime left a large warehouse full of boilers, scores of them. Very few exploded, but the bagged fireboxes were a sight. The practical man in charge of the water system was very short, very fat, very profane, perhaps largely in consequence of his occupation. He was quartered in the room directly under the writer's. His first knowledge of water trouble was usually from some early riser above who wanted a shower, in vain.

A large fraction of the supply was used for boiler feed for both land and floating equipment. The filling of tanks began early and by 6 A.M. the pressure was usually too low to fill the second floor showers. Water could be drawn from faucets lower down for a half hour more. Those who rose later must needs go downstairs and perhaps across the street for any water at all.

Much of this loss of pressure was due to the laziness of the blacks, who never dreamed of shutting a valve. "Throw the hose overboard and forget it" was their rule; *they* needed no water. So it ran to waste all day perhaps, or until some white man saw it.

The boilers generally shut down at 6 P.M. and by 10 P.M. there was usually water all over the town.

This supply was soft, fairly clear, excellent for the toilet, but as it was surface water from a drainage area inhabited for the most part by people whose ideas of sanitation were not far advanced, it was not at all safe for drinking. A galvanized-iron tank screened from mosquitoes, located at a corner of each house and supplied from the roof, furnished a drinking supply for the greater part of the year. These were analogous to the barrels already mentioned in the old town, and, like them, were the occasion of solicitous regard on the part of the sanitary inspectors lest mosquitoes multiply, and therefrom yellow fever. All water barrels and tanks had screens permanently fastened on. They were usually elevated on blocking or low stands, spigots were provided and the natives strictly forbidden to meddle in any way with the screens, on pain of having the barrels summarily destroyed. The penalty for meddling by canal employees was even more drastic. To guard against the annual dry season, this potable supply was reinforced by some half dozen large tanks eight or ten feet in diameter and

fifteen or so high, replenished from near-by roofs and delivering through the ancient French fountain already mentioned.

The wisdom of so reinforcing the weather was abundantly demonstrated during the drought of 1906. The writer has as a souvenir an order for water covering this period. The dry weather was in its way a godsend, giving opportunity for much needed pipe and drain laying, building of streets, and the like.

This temporary supply, both surface and rain storage, was, in the summer of 1906, succeeded by a more permanent arrangement. The authorities of the canal work had early foreseen the need of abundant water for Colon and Cristobal. Surveys and plans had been made, a reservoir site selected, well selected at that, pipe lines laid out, and construction was well in hand when the writer arrived on the scene. The construction forces were located in a most charming camp on the edge of a hill forming part of the proposed main dam. A narrow gage railway had been laid, diminutive locomotives, when not off the track, brought in supplies, cement, tools, and the like, not to mention our strenuous President Roosevelt on his precedent-breaking trip to the canal. A twenty-inch pipe line was being built under great difficulties, from near the proposed gatehouse toward the town. Of this pipe line material a surprisingly large fraction had suffered in transportation or earlier; the line was littered with short ends cut from the cracked cast-iron pipes (Plate II). In the meantime, pipes were being laid in the town, hydrants set, and preparations made to distribute the water. Pending the arrival of the main pumps, temporary pumping stations were established, located at diverging points in the pipe lines, and designed as boosters to take the water from the gravity main, at a pressure sometimes less than atmospheric, and deliver it back into the main beyond the pumps at a pressure sufficient to serve two- and three-story buildings.

It was anticipated that there would be delay in the delivery of pumps and standpipe, and in the construction of the main dam. A small temporary dam was accordingly built across an arm of the proposed reservoir, and an 8-in. spiral riveted pipe nearly a mile long was laid on the surface of the ground connecting from it to the permanent 20-in. pipe below the main dam. This was ready for service early in 1906. About that time the earlier reservoir in the

DEFECTIVE ENDS OF PIPE ON COLON LINE.

diversion channel ran dry, and a connection near it was made to the pumps, and the reservoir water was delivered to the town through the original pipes laid at about the beginning of the United States administration. This water was of excellent quality and we thought our troubles were over, but, alas, the dam leaked, the formation was like a sieve; a few weeks saw the end of that supply. The situation looked so desperate that an order was issued to abandon all upstairs baths and toilet appliances. This order, dated April 1, was to be effective April 4. Late in March, some one discovered that a few feet from the pumps was a branch of the old diversion channel ten or more feet deep, full of water, connected at the other end, a mile or so away, with several full rivers, and at a greater distance with Limon bay and the ocean. A couple of lengths of pipe did the trick. Several days before the above-mentioned order to close toilets became effective, we were startled by the appearance, early in the evening, of fireworks from the phosphorescent salt water in our dark shower baths. Although the occasion for closing was thus averted, the order was nevertheless enforced and for a month we were denied the use of our toilet facilities in second stories, notwithstanding the fact that the pressure was ample, far better than at any time for six months preceding or following.

An amusing incident shows how little the situation was understood at Washington. The *Post* of that city published an article describing the water famine at Colon. The administration gravely explained that there was no water famine, there were 2½ million gallons of water held as reserve in the temporary reservoir. The writer happened to visit the reservoir at just this time and saw the 2½ million gallons — the surface was some three feet below the intake to the pipe line.

The salt or brackish water, excellent for sanitation, was, of course, unsuitable for boilers, consequently the old French reservoir across the bay was put in commission, barges were filled and towed across to serve the dredge fleet, shops, etc.

The native town was still unsupplied with drinking water. After a few days of rioting, not reported in the press, the railway came to the rescue, put its up-country pumps and tank cars in commission, and Colon began to drink again.

About this time Washington began to ask about the progress on the cold storage plant. Assurances were given that the refrigerator cars which had already been delivered were running regularly on the railway. So they were; they made excellent water cars. They were so tight that a very little bulkheading made the most efficient of tanks. The ice for these cars was ready about a year later.

Washington also took a fall out of the salt water supply, the details of which would require too much space to recount here. Quibbles and explanations, very ingenious, were the order of the day.

So it went till early in May the rains began, the runoff caught up with the leaks in the temporary reservoir, the salt water supply was replaced with fresh, and the pressure in the upper stories resumed its high night and low day schedule and we were allowed to resume the use of our toilet rooms.

During most of this time the Panama city supply was better than ever before. (It was the first dry season of the improved new supply.) Toward the middle of April, however, the supply was drawn below the gate chamber inlets. A most ingenious raft was built with pontoons of 16-in. sheet-iron dredge pipe, a pump was mounted thereon, steam supplied from a boiler on shore, and the water was pumped into the gate chamber. The writer saw the raft under construction; the water was warm, the negroes were just short of naked, so the hardship was rather on the consumers than on the workmen. The Panama end has, however, a story of its own.

To return to the Colon and Cristobal story. The new 20-in. pipe line was now nearly enough complete to be used, mains were laid in many of the streets, local pumps in several places were taking water from the 20-in. main and supplying sections of old mains; the distribution system was not in use, gates were closed, there were no hydrant wrenches, nor house connections.

Inventory day was approaching, and on June 6 a fire broke out in the oil house of the commissary store. After some forty minutes hose was brought from the main warehouse a mile away, pipe wrenches were secured and several hydrant streams were playing on the ruins. The fire had one good result, — the hydrants and

distribution systems were kept under pressure and the pumps at the diverging points above mentioned were kept going. Some weeks later house connections were made and local trouble from limited quantity of water was at an end. In due course of time the main reservoir was put in commission, bettering the pressure, as it cut out the mile of 8-in. supply pipe. Still later pumps were installed, supplied by steam through several hundred feet of pipe carefully insulated, being buried in a bed of concrete in a deep trench.

This steam pipe line was put in to avoid tramming the coal the several hundred feet to site of pumps. Later oil fuel was substituted, and still later the boilers were moved to the pump station, after tests had shown a remarkable steam comsumption for this station. Published tests showed 53 lb. per indicated horse-power. These permanent pumps allowed the elimination of the local pumps scattered over the town, and further improved the pressure. On the completion of the standpipe on a nearby hill, the system was complete.

But the troubles had only begun. The water was stored under the tropic sun, the inevitable algæ appeared, plans were made for chemical treatment, a settling basin was prepared, made of concrete, partly on a new fill, which gave all kinds of trouble by cracking, before water could be kept in it. Pressure digesters were put in, gaging and storage tanks for alum were built, pressure filters of a modern type were connected up, Venturi meters provided, and the quality of the water improved. The watershed had already been surveyed and practically all the inhabitants removed. The water unfiltered was safe, and the bacterial content very low, only the algal growths were troublesome. The filters removed them very satisfactorily, delivering 50 to 67 million gallons monthly of clear sparkling water, in all respects as good as many of our best city water supplies in the North.

The filters developed an unexpected phenomenon in that the material evidently segregated; two of the four reduced the bacteria some 75% or more, the other two in some cases increased the bacterial count (560 raw to 18 000 filtered). The colon bacillus did not appear.

It has already been stated that the main pipe line was built

under difficulties; the same was true of the distributing pipe system; the material was not wholly suitable; the writer has counted eight or ten lead joints between a hydrant and its Tee on the street main; it was, therefore, not a surprise to him, on seeing the station Venturi graphs, to note that the night flow (after midnight) was more than 50 per cent. of the usual day flow.

About June of 1906, Congress decided to build a lock canal with locks at Gatun. Surveys were pushed, a town laid out in an upland pasture, tents were pitched to shelter the town builders, and measures taken to secure water for temporary use. Boilers and pumps were installed on the Gatun River a mile away, pipe lines laid, some of the rain-storage tanks formerly used at Cristobal were set upon a high trestle on a hill, altogether some 160 ft. above the pumps, and the town was rapidly built. The writer was, with the construction division officers, transferred to Gatun about March, 1907. The mud was knee deep, two deep cuts were being made between the town and the railway, things were crude generally, but the quarters were comfortable, we could get plenty to eat, such as it was, the work was very interesting, and best of all, we had unlimited water. The Gatun River, a stream of considerable magnitude, drained a good sized bit of country; the exact area was not at last accounts known. The watershed was diversified, some open pastures, much jungle, rather more penetrable than in other parts of Central America, and supported a considerable population. Colon bacilli were always present, so our health department had all houses provided with distilled or at least sterilized water (usually distilled) for cooking and drinking. The town supply was excellent for all other purposes. The twofold supply reinforced for boilers by another storage tank proved adequate and was subject to interruption only from pump breakdown, as the tanks were small. The river sometimes rose to the eaves of the pump house. A dike was built around it and an emergency pump was installed on higher ground, to be used if necessary. The writer recalls only one occasion when it was used. To provide storage a tower tank of some 400 000 gal. capacity was ordered (Plate III, Fig. 2). On arrival it was assembled, taking some five months in the process. When complete, the tank would not hold water; even pneumatic rivet guns could not beat the black laborers.

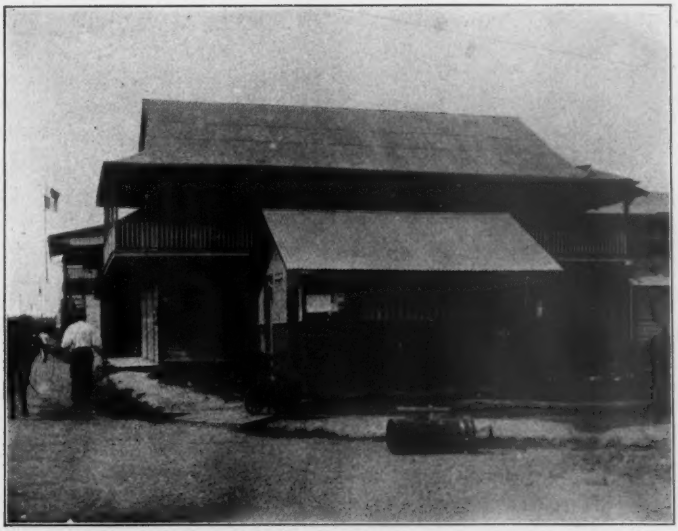


FIG. 1.

WATER STATION, COLON, 1906.

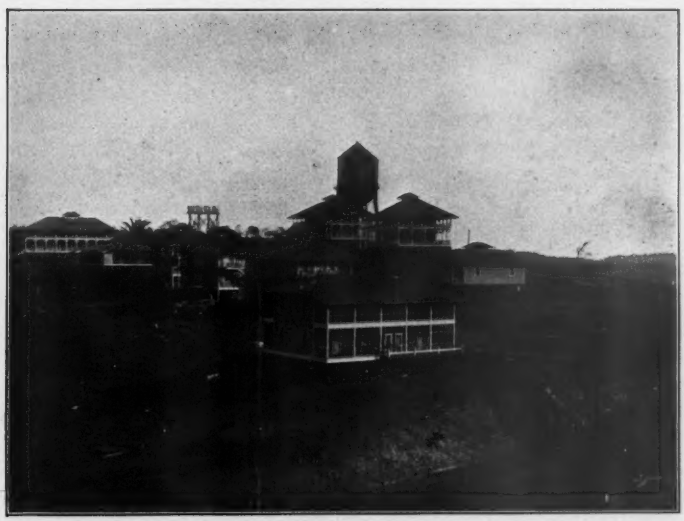


FIG. 2.

TANKS AT GATUN.

A two-inch coat of cement stopped the leaks, and the tank had not failed at last accounts. About 1909 an electric-driven multi-stage turbine pump was installed, as the older pumps were wearing out.

The supply still lacked perfection as the pumps were some 85 ft. below the level of the proposed lake, which it was proposed to start filling about 1910. Surveys were accordingly made and a site selected for a permanent reservoir. Studies and estimates were made, some of them by the writer, at that time in charge of the Gatun drafting force, for several types of dam, concrete, earth, and earth-faced rock fill. The latter proved most economical as rock and earth were available from the lock excavation less than two miles away. A nearby saddle provided an excellent location for an 80-ft. concrete waste weir. A concrete gate chamber was built, on a pile foundation, also a concrete core or cut-off wall some 100 ft. long; the reservoir site was cleared, the watershed depopulated, a trestle built, and work was started on the dam. Barring sundry freshets, the dam was built without encountering many of the difficulties contended with during the early days of the Colon supply.

A pumping station was designed, with two multi-stage turbine pumps, motor-driven from the main power station a mile or so away, switches were provided to automatically stop and start motors according to stage of water in the storage tank, and Venturi meters, valves, etc., to control the plant. It went into commission in May, 1910.

Analysis of the water (Quebrada las Guacas) indicated that its quality would be a close duplicate of the Colon supply (Quebrada Brazos). The experience there, therefore, was available, and trouble from algæ was expected. It was accordingly thought best to provide for filtration. Several studies were made, none of which seemed to be satisfactory. The writer, being about to leave the service, having nearly completed a continuous four-year term, was detailed to study the problem and report on a suitable plant.

The water of Quebrada las Guacas is in composition and alkalinity essentially similar to that of Brazos Brook, used for Colon's supply. The experience gained at Mount Hope filters thereby becomes available for guidance.

It has been found that these waters can most readily be filtered after the bulk of the organic matter has been removed by coagulation with alum. The operations at Mount Hope had not then been extended over sufficient time to afford a reliable indication as to whether or not lime would be necessary. The plans, however, provided sufficient room for an elevated lime-water tank over the alum tanks if it should prove necessary.

The design is believed to be sufficiently elastic to allow the use of other coagulants in case experience indicates their desirability.

In the use of alum as a coagulant, experience has shown that thorough and immediate mixing of coagulant with the raw water is essential to success. The vortex method, while not so well precedented, promised to be effective and call for much less loss of head than the more usual succession of weirs. It was, therefore, chosen as best adapted to the operating conditions.

The water from the reservoir is admitted through a 16-in. gate operated by a float-controlled hydraulic cylinder. The float valve has an adjustment on the float stem to provide for varying the output of the plant, and on the valve lever to vary the sensitiveness of the valve. An air check valve in the pressure line was provided to allow the gate to close by gravity if for any reason the pressure should fail. In case the consumption increases to such an extent that the float does not operate properly, it can be removed to a special float chamber suitably connected by piping with the mixing tank.

The pipe line from the reservoir to and through the regulating valve was made up of standard fittings, the only special being the nozzle through which the water is delivered to the mixing tank.

This pipe line is provided with a by-pass through which, in case of emergency, raw water can be delivered to the pumps direct; also a pressure line through which the water near the bottom of the reservoir can be pumped to the filters in case it is ever found necessary to consume this lower portion of the water storage.

The coagulant is intended to be dissolved in pressure digesters in the chemical storage room in much the same manner as practiced elsewhere, the solution delivered by the force main pressure into the solution tanks, each of which is intended to hold one day's supply. From the storage tanks the solution is delivered through

float-controlled valves to one of two orifice tanks. These valves can be connected to deliver from either storage tank to either orifice tank, or, if preferred, to the adjacent one only.

The orifice tanks are provided with plate glass fronts. It is intended that this glass shall have a graduated scale and a series of orifices ½-in. and ¼-in. diameter. The float valves having adjustable stems, it is possible to vary the head on the orifices and also the number of orifices, thus allowing a large variation in the amount of discharge to accommodate variations in the quality of raw water, the actual discharge to be determined by careful calibration. From the orifices the solution falls into brass or copper funnels connected by pipes of brass or copper with a perforated distributor in the raw water nozzle.

The raw water with its dose of coagulant is admitted to the circular mixing tank in a tangential direction, and after making the circuit of the tank several times is drawn off at the bottom through a 16-in. inverted siphon to a channel, from which it flows in a thin sheet over a weir to the sedimentation basins. The inverted siphon is provided with a drain by which all the water in the coagulant house can be removed when necessary for inspection or cleaning.

The sedimentation basins are designed of sufficient size to allow about one hour or more for the separation of the sludge or precipitate of aluminum hydrate, with most of the grosser impurities, and its subsidence to a point well below the surface.

A submerged weir is provided at mid-length of the sediment basin by which it is expected that the waste of water caused by drawing off the sludge may be materially reduced. Experience indicates that most of the sludge will be deposited in the first basin and can be drawn therefrom at more frequent intervals than from the second basin. The basins are further divided by a drain gallery allowing the basins to operate at half capacity when, if necessary, one section is drained for more thorough cleaning.

It is expected that the ordinary cleaning will be accomplished by drawing off the lower layer of water and sludge, closing the valves when clear water appears at them.

The basins are provided with multi-hopper bottoms, from the apices of which drains lead to a series of controlling valves in the

drain gallery. This gallery is also intended to afford drainage to the filters and to the coagulant and mixing tank and to discharge through a 24-in. circular drain to the brook.

In case experience shall indicate its necessity, provision is made for a system of perforated pipes on the ridges of the hopper bottom through which water under pressure can be discharged in order to wash the sludge from the slopes of the hoppers.

The walls of the drain gallery are to be finished one-half foot lower than the outer walls, to provide, besides economy, a safeguard against the plant overflowing and washing out its foundations, an important item with black attendants. In case the regulating valve should fail to close, the water will run to waste from the sedimentation basin over the wall to the drain gallery.

A grill floor is intended to rest on the ledges and allows access to the valves just below. It is intended that these valves should be of the sluice gate, lever-operated type.

From the sediment basins the water is skimmed by a weir and delivered through a 16-in. pipe and 10-in. valves to the individual filters. From each filter the water is collected in perforated pipes and discharged through an automatic regulator and a 16-in. effluent pipe to a clear water well or reservoir. The filters are 17 by 16½ ft. and are intended to discharge 500 000 gal. each per day, at a rate of about 80 million gallons per acre per day.

It was proposed to import the sand.

Provision is made for a 10-in. wash water line, taking water from the force main or pump, a 6-in. air line and a 16-in. drain line discharging into the drain gallery of the sedimentation basins. The filter pipe gallery is also drained to the sediment basin drain gallery as shown.

A covered operating gallery may, if desired, be built over the filter pipe gallery. This will allow the valves to be locked up and protected.

The clear water well is made circular in plan to attain maximum economy.

In regular operation it is expected that from one to three grains per gallon of alum will be used. The coagulant basins will be cleaned at intervals of twelve to forty-eight hours, as may prove necessary. The filters will be cleaned at shorter intervals as often

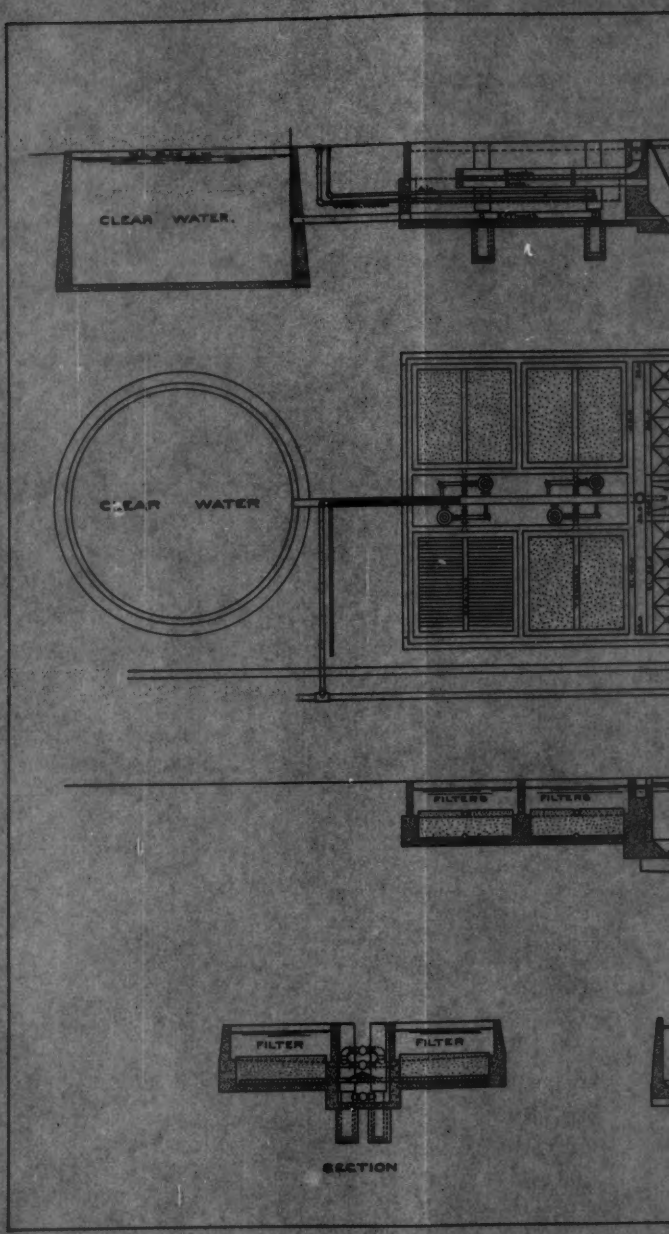
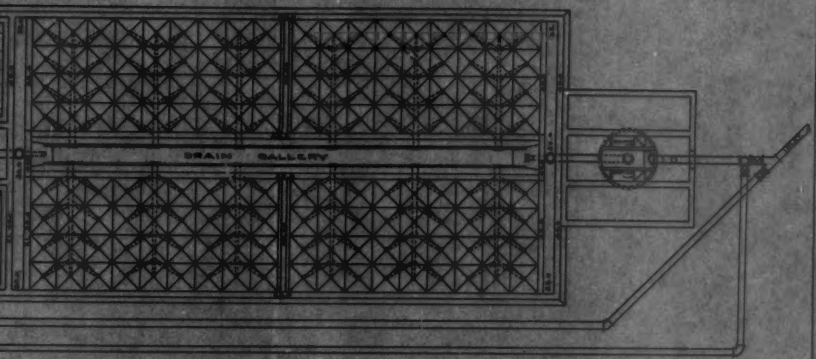

CLEAR WATER.
CLEAR WATER
FILTER
FILTER
SECTION

PLATE IV.
N. E. W. W. ASSOCIATION,
DECEMBER, 1911.
HIGGINS ON
FILTRATION AT PANAMA.

CENTER SECTION



SECTION THRO BASINS

SECTION

STUDY
for
TROPICAL FILTRATION

Scale

The New England Water Works Association

775 TREMONT TEMPLE

BOSTON

8 NOVEMBER, 1911.

It is intended to devote the regular meeting of December 13, 1911, to the subject of Steel versus Wrought Iron for Service Pipes, and The Influence of Methods of Manufacture, especially galvanizing, upon the durability.

It is desirable to have a complete discussion of this subject, and all who can be present are urged to come prepared to give the Association the result of their experiences.

EXECUTIVE COMMITTEE.

as the operating head reaches about nine feet. An indicator on each regulator float will show this head at all times for each filter, and an electric bell alarm can easily be provided.

Such fancy devices as marble operating tables and hydraulic valves have not been shown, as they are not at all necessary for a plant of this size under Isthmian wage rates.

The material for the filters, tanks, basins, etc., is in most cases reinforced concrete of the simplest possible design, to reduce as much as may be the cost of false work and forms required. The reinforcement has been liberally used, and the plant has been made substantial, to insure as low maintenance charges as possible.

The piping is intended to be cast iron rather than wrought, as the former will be less affected by the chemicals used; valves to be cast iron, bronze faced and lined, bronze stems; floor stands and hand wheels are provided for the filter valves.

Provision was made for considerable future enlargement of this plant if the demand for water should increase to a marked extent. Space was provided, between filters and the clear well, for an additional pair of filters, and the piping was designed to allow their installation with a minimum of expense.

The plan appended (Plate IV) is intended to show the features incident to the foregoing; it is not an exact copy of the plans prepared for the Gatun plant.

DISCUSSION.

MR. ROBERT S. WESTON. I have been very much interested in this paper because it brings up a problem in water purification which has been quite prominent for some time and is coming into greater notice. We all listened with a great deal of interest to Mr. Wasteneys' excellent paper [1] at Gloucester last September, in which he described experiments on the feasibility of purifying a water of this same class at Brisbane, Australia. It seems that many tropical waters carry a great deal of gelatinous, organic suspended matter which is so fine that it is almost in solution. Under certain conditions this organic matter settles out very rapidly. Of course it can be coagulated out; it can be loaded with

[1] JOURNAL N. E. W. W. A., Vol. XXV, p. 422.

alum and lime and precipitated. This has been the method described to you this afternoon. Mr. Wasteneys has worked out a solution of this problem based upon the oxidation of the oxidizable material in the water to such a degree that it will precipitate or be removed from the water by ordinary methods of filtration and without using a coagulant, or with the use of very little coagulant.

The same problem though of lesser degree was presented to Mr. Hazen at Springfield, where the water at the Ludlow Reservoir, which was very highly loaded with organic matter, was purified by intermittent filtration. It has also arisen at Athol, Mass., and at Charleston, S. C. It would seem as a general thing that the more economical way of treating this class of waters would be first to oxidize the dissolved matter; that is, to try to apply methods used for the treatment of sewage, in order to remove the food material which forms the basis for growths of algæ and renders purification by ordinary filtration methods difficult, rather than to depend entirely upon slow sand or mechanical filtration methods so useful in a temperate climate.

The operation of the works at Panama, which have just been described here, has within the last few months been noted in some of the engineering papers, or at least in a paper before some engineers' society. If I remember rightly, quantities of coagulant greatly in excess of the one to three grains per gallon estimated had to be used, because this organic matter was in such a condition that it wasted a large amount of coagulant before the coagulation was effected.

THE PRESIDENT. I have enjoyed very much listening to the paper, and I would like to ask the author if intermittent filtration was tried on the isthmus at all, experimentally or otherwise.

MR. HIGGINS. It had not been up to the time I left. We did not have space for it at this particular plant, that is, within a reasonable distance.

THE PRESIDENT. I have had the feeling that intermittent filtration was more economical and also efficient than any other method for these waters containing heavy loads of organic matter, and also abundant iron. The secret of success at Ludlow as at Brisbane is that the water carries plenty of iron, and iron is a

natural coagulant, just as efficient as an artificial coagulant, if it can be handled so as to make it available. Iron is abundant on the isthmus. About 10 per cent. of the weight of the whole isthmus is metallic iron, and it would certainly seem that the iron in the water could be made to coagulate the organic matter in intermittent filters if it is handled right.

NOTES ON TYPHOID FEVER AT WASHINGTON, D. C.

BY W. T. SEDGWICK.

[*Read November 8, 1911.*]

It occurred to me, gentlemen, that it might interest you to hear a very late word concerning the Washington, D. C., situation, with reference to the water supply there. You will remember that when the filters went into operation in Washington, typhoid fever was not reduced, and that a lot of people said it must be that the filters were worthless, since the typhoid was comparatively high, and it had been expected that it would be materially lowered. At that time various local authorities, some of them of a good deal of weight, frankly expressed the belief that the filters were ineffective, and that typhoid fever in Washington was still coming from the Potomac River. But on careful examination a number of us felt perfectly certain that the filters were all right — I mean unprejudiced outside parties who had had nothing to do with the filters whatever, or with their construction. The engineering journals, you remember, contained many articles dwelling upon the various aspects of the subject, and it was one of the most interesting problems of the day.

The main fact stood out, however, that the bacterial efficiency of the filters was very high. Oftentimes they would run for months with an average bacterial discharge of less than 20 per cubic centimeter, and with large numbers only during the winter, or at times when there was no typhoid fever to speak of in the city; so that it proved to be practically impossible to connect in any way a lack of bacterial efficiency in the filters with the typhoid fever prevalent in Washington.

The United States Public Health and Marine-Hospital Service soon went to work (in 1906) on the matter of typhoid fever in Washington, and some of the investigators, at any rate, were at first disposed to blame the typhoid upon the filters, so that there is no question but what they made a most thorough and in one sense

unprejudiced study of the situation. And they have published for every year from 1906 to 1909 valuable reports on typhoid fever in Washington. It so happens that I have to-day the advance sheets of what is likely, I suppose, to be the final report, namely, that for 1909, certainly the latest one up to the present time, which has been made by experienced persons, chief among whom is Dr. Lumsden. I have been going over it rather carefully this morning and with great satisfaction, and I think any of you water-works men would share my satisfaction. For these able investigators, who have now become exceedingly expert in typhoid fever investigations, as a result of their long labors, say that there is no good evidence (and in my opinion there never has been any satisfactory evidence) that the typhoid fever in Washington ever proceeded from any inefficiency or imperfections in the filters.

Of course that raises the question, What then is the typhoid in Washington due to? — and they trace it to various factors within the city, — the peculiar diverse population, largely composed, as it is, of negroes; the extraordinary opportunity offered by the peculiarities of Washington life for contact infection, which is only another name for the spread of disease by contagion; to milk, which is here charged, as everywhere to-day, with some of the principal burdens of typhoid fever transmission; and in this particular report more than any other, to oyster infection. Washington is, as you know, and Baltimore and Richmond also, are centers of the oyster trade, and the eating of raw oysters in those cities, located as they are very near the shores of Chesapeake Bay, a great natural oyster bed, is everywhere practiced. Very careful investigation has made it seem pretty likely that a good deal, a very considerable percentage, of the typhoid fever in Washington comes from that use of raw oysters.

This is one of the newer things in the last report of these investigators; and, summing it all up, they find that there is a great variety of things responsible for the comparatively high typhoid fever in Washington. What you and I are particularly interested in, however, is the fact that at last the water filters are, in the opinion of everybody, I think, who is competent and who has looked into the subject to any extent, relieved of any serious burden in the causation of typhoid fever in that city.

PROCEEDINGS.

November Meeting.

Hotel Brunswick,
Boston, Mass., November 8, 1911.

Mr. Allen Hazen, President, in the chair.

The following members and guests were present:

Honorary Member.

William T. Sedgwick.

Members.

S. A. Agnew, Randolph Bainbridge, M. N. Baker, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, F. A. Barbour, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, George Bowers, E. C. Brooks, J. C. Chase, R. D. Chase, M. F. Collins, W. R. Conard, J. H. Cook, H. P. Eddy, E. D. Eldridge, F. F. Forbes, A. N. French, A. S. Glover, Clarence Goldsmith, J. M. Goodell, R. A. Hale, R. K. Hale, F. E. Hall, J. O. Hall, W. E. Hannon, Allen Hazen, M. F. Hicks, H. K. Higgins, H. G. Holden, J. L. Howard, A. W. Jepson, E. W. Kent, Willard Kent, F. C. Kimball, G. A. Kimball, A. C. King, J. J. Kirkpatrick, H. O. Lacount, H. P. Letton, N. A. McMillen, A. E. Martin, F. E. Merrill, William Naylor, E. B. Phelps, L. C. Robinson, P. R. Sanders, C. W. Sherman, G. A. Stacy, E. L. Stone, W. F. Sullivan, H. L. Thomas, R. J. Thomas, C. T. Treadway, W. H. Vaughn, R. S. Weston, F. B. Wilkins, F. I. Winslow, G. E. Winslow. — 62.

Associates.

The Anderson Coupling Company, by W. D. Cashin and C. E. Childs; Ashton Valve Company, by C. W. Houghton; Harold L. Bond Company, by Harold L. Bond; Builders Iron Foundry, by A. L. Coulters; Darling Pump and Manufacturing Company (Limited), by H. H. Davis; Hersey Manufacturing Company, by A. S. Glover, W. A. Hersey, and J. A. Tilden; Lead Lined Iron Pipe Company, by T. W. Dwyer; Charles Millar & Son Company, by C. F. Glavin; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by Charles H. Baldwin, H. L. Weston, and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; Platt Iron Works Company, by F. H. Hayes; Rensselaer Valve Company, by C. L. Brown; Thomson Meter Company, by E. M. Shedd; Union Meter Company, by F. E. Hall; United States Cast Iron Pipe and Foundry Company, by D. B. Stokes; Henry R. Worthington, by Samuel Harrison. — 21.

GUESTS.

D. B. Smith, Portland, Me.; W. H. McCann, Lewiston, Me.; J. G. Hill, Lowell, Mass.; R. H. Hunt, Worcester, Mass.; E. B. Carvey, Lowell, Mass.; William Fieldman, E. H. Smith, R. E. Hall, Boston, Mass. — 8.

The Secretary read applications for membership, duly approved, of James A. Cushman, Clinton, Mass., engaged in construction and maintenance of Wachusett reservoir, dam, and aqueduct; John Ware, Downey, Ida., formerly division engineer, Baltimore & Ohio Railroad, later connected with the Boston Elevated Railway Company, and now with Downey Water Company.

On motion of Mr. Bancroft, the Secretary was directed to cast one ballot in favor of the applicants, and, he having done so, they were declared duly elected.

The Secretary read the following communication:

BILLERICA WATER WORKS.
OFFICE OF WATER COMMISSIONERS.
NORTH BILLERICA, MASS., November 7, 1911.

NEW ENGLAND WATER WORKS ASSOCIATION, BOSTON:

Gentlemen, — It is the custom with us when application is made for service to have it signed by the owner of the property. In many instances it has come about that the owner has died and his property has passed into the hands of the estate. We would like to get some information as to whether or not it is the usual custom to secure new signed applications from those who take charge of the estate, and would ask you if you would have this come before your meeting. Any information you might be willing to offer us would be gratefully received.

Yours very truly,
(Signed) BILLERICA WATER COMMISSIONERS.
C. W. MORTENSON, *Clerk*.

THE PRESIDENT. Can some of our members answer this inquiry, as to what their practice is?

MR. SAMUEL A. AGNEW. That question has come up with us at Scituate a number of times, and I have often wondered what to do about it. We have never yet required a new owner to sign another application, as we call it, but I have expected to have difficulty just on that very score. I am glad this matter has been brought up.

MR. ROBERT J. THOMAS. We do not require any new application in Lowell, and we have never had any trouble.

MR. M. F. COLLINS. It is the same way in Lawrence, Mr. President.

MR. RICHARD D. CHASE. In New Bedford an application for a service is signed by the owner and reads that it shall continue until revoked in writing. If the property passes to an estate this signature would still hold. If the premises are sold and the first application is not revoked, the bills are sent to the former owner and naturally he settles with the new owner. It is unfortunately true that in Massachusetts water rates are not a lien upon property, but in practice by exercising the right to shut off the water it never fails that some one comes in and settles for back dues. This is really the one sure means of getting bills paid.

MR. JOHN O. HALL. I think in some cases it is the practice to put upon the form of application a printed statement that the charge becomes a lien upon the estate; then when an application is signed at the office it binds the estate.

MR. AGNEW. That might apply to municipally owned plants, but would it apply to a private corporation?

MR. HALL. The agreement would be the same if it is a private corporation, and the blank was signed; it would be in the form of a contract.

MR. GEORGE A. KING. We don't require any new application in Taunton. I would like to inquire what the use is of having any application in writing from anybody.

MR. PATRICK KIERAN (*by letter*). In Fall River we do not require a new application when a piece of property passes to an estate. We do require an application when property is transferred from one person to another.

The first paper of the afternoon was entitled, "Has the Time Come for Double Municipal Water Supplies; One Naturally Pure for Drinking and Cooking, the Other, Denaturized or Sterilized, for All Other Purposes?" by Prof. W. T. Sedgwick and H. P. Letton, C.E., Massachusetts Institute of Technology, and was read by Mr. Letton. The paper was discussed by the President, Mr. Charles W. Sherman, Mr. Arthur N. French, Prof. E. B. Phelps, Mr. Randolph Bainbridge, Mr. Frank C. Kimball, Mr.

John H. Cook, Mr. George A. Caldwell, Mr. John C. Chase, and Professor Sedgwick.

Mr. H. K. Higgins, consulting engineer, Boston, Mass., read a paper in which he gave an account of the development of the water supply and the installation of the filtration plant at Panama. The President and Mr. Robert S. Weston spoke particularly with reference to the problem of filtration.

Professor Sedgwick made a statement concerning the latest results of the investigation as to the efficiency of the water filters and the causes of typhoid fever in Washington, D. C.

The President announced that next month the Executive Committee were planning for a "red-hot" meeting, the subject of which would be "The Material for Service Pipes; whether Wrought Iron or Steel, and How to Treat It." He said that it was expected representatives of various manufacturers would be present to tell what they knew of the methods of manufacture and the merits of the different kinds of pipe, and requested a large attendance of the members.

Adjourned.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Wednesday, November 8, 1911.

Present: President Allen Hazen and members Michael F. Collins, John J. Kirkpatrick, Lewis M. Bancroft, Richard K. Hale, Robert J. Thomas, and Willard Kent.

Two applications for membership were received and recommended for admission, namely:

John Ware, assistant treasurer Downey Water Company, Downey, Ida., and James A. Cushman, engineer of construction and maintenance on Wachusett reservoir, dam and aqueduct, Clinton, Mass.

It was *voted*: That the December meeting of the Association be devoted to the discussion of "Steel *v.* Iron Service Pipes, Galvanizing, and Other Methods of Protection."

Adjourned.

WILLARD KENT, *Secretary.*

BOOK REVIEW.

HOME WATER WORKS. A MANUAL OF WATER SUPPLY IN COUNTRY HOUSES. By Carleton J. Lynde, Professor of Physics in MacDonald College, Quebec. 5 x 7½ inches, xii + 270 pages. 106 text figures. New York: Sturgis & Walton Co. Cloth, 75c. net.

This little book is one of "The Young Farmer's Practical Library," and in it the author presents in simple language a general description of the requirements of a water supply suitable for the country home or farm.

The author gives a brief description, including the materials needed and the cost, of various designs, and shows how such systems may be installed at very slight expense.

The sources of water are then discussed, with a general description of springs and different kinds of wells, the proper methods of construction and the equipment required.

By far the largest part of the book, however, is devoted to a discussion of the elementary physics of pumping and a description of different types of pumps, windmills, tower tanks and pneumatic systems, and the general methods employed in connecting up pumps and engines.

There is also a short chapter on water power, giving a brief description of different kinds of wheels and the methods of connecting them.

In the last chapter the author considers in rather a brief way the problems of plumbing and sewage disposal. The book closes with a list of firms dealing in water supply and plumbing materials.

This is a very good book to recommend to people being out of reach of municipal supplies, for it shows that satisfactory systems can be installed, at very slight expense, which will give much better service than the old-fashioned well from which the water has to be carried to the house.

JOURNAL

OF THE

New England Water Works Association.

VOLUME XXV.

1911.

PUBLISHED BY
THE NEW ENGLAND WATER WORKS ASSOCIATION,
715 Tremont Temple, Boston, Mass.

The four numbers composing this volume have been separately copyrighted in 1911 by the New England Water Works Association.

The Fort Hill Press
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MEMBERSHIP.

ADDITIONS.

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City Engineer, Westfield, Mass.

Miller, Walter E.
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Young, Alfred A.
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Frost, George H.
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Assistant Engineer, Public Works Department, High Pressure Service, Room 18, Old City Hall, Charlestown, Boston, Mass.

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Potter, Philip A.
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76 White Street, East Boston, Mass.

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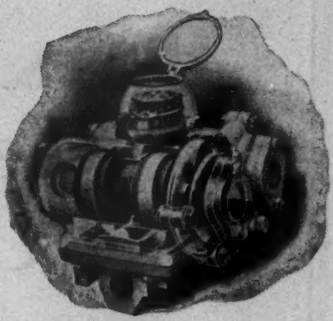

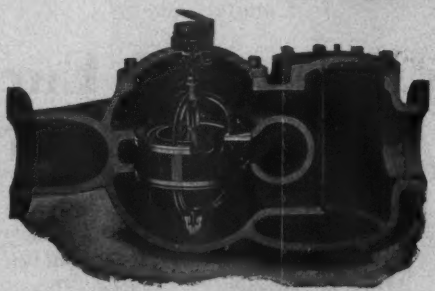

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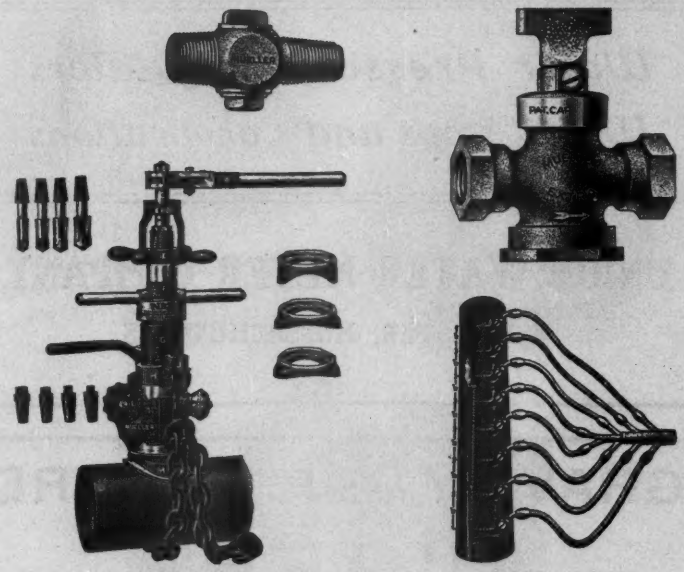

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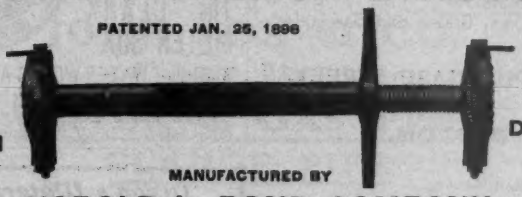

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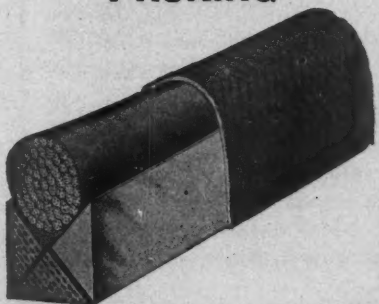

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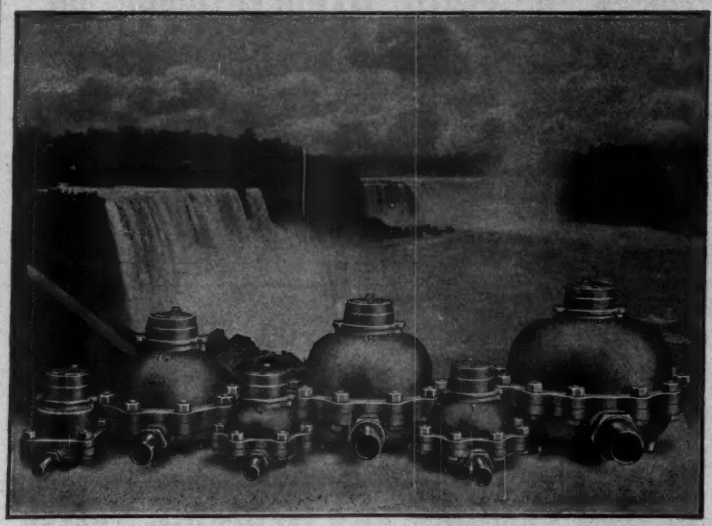

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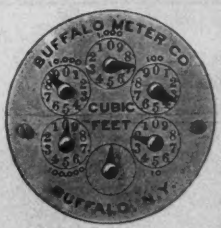

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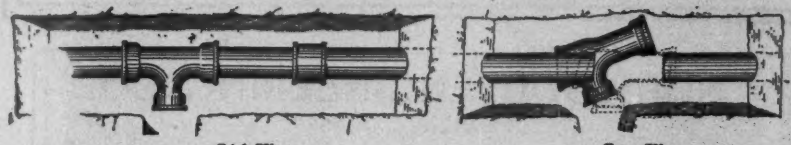

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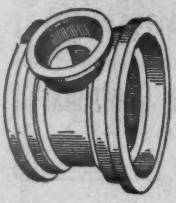

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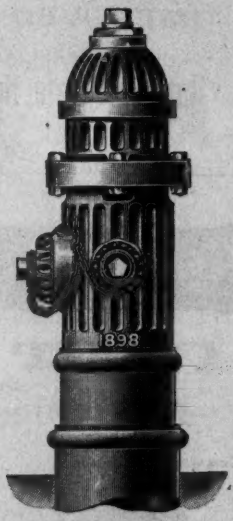

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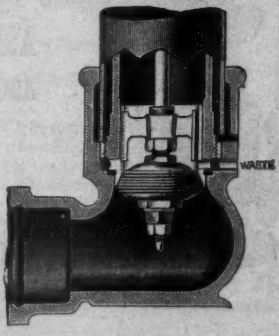

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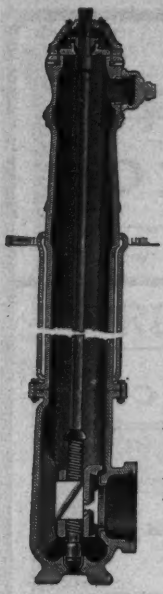

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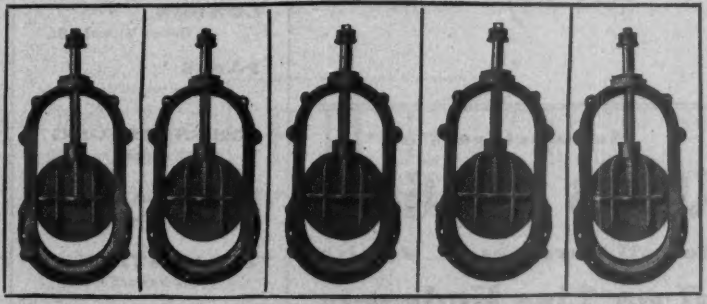

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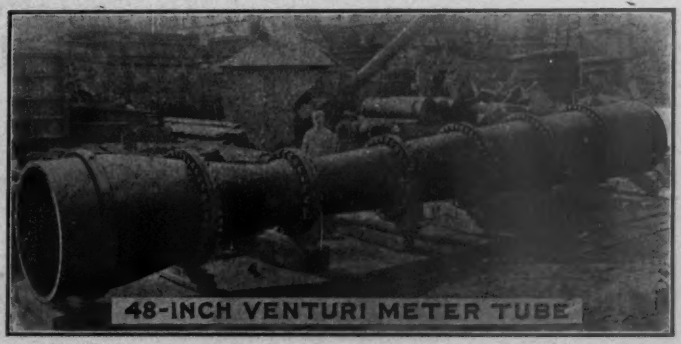

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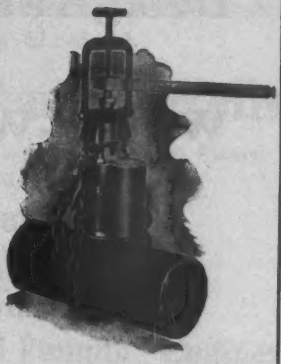

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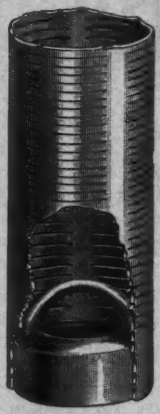

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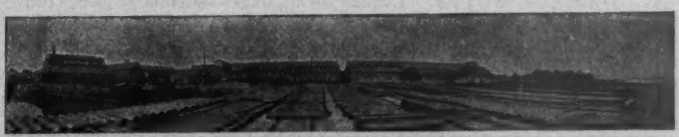

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